Appendix A

Plant development, arthropod populations, experiments, and production costs

Plant Development and Yields

Plant density differences between treatments. In the 1996 production season, results were potentially confounded by density differences among the treatments. Specifically, the organic component of the enrolled BASIC fields were on average planted at 30,000 plants per acre, while check fields and non-organic BASIC fields were on average about 50,000 plants per acre.

This same issue came up during the 1997 season, with a slight difference: organic and non-organic BASIC fields were both planted at a lower density than were conventional fields (organic BASIC, 39,000 plants per acre [ppa]; non-organic BASIC, 42,500 ppa; conventional, 58,800 ppa). By the end of the season, organic fields had lost slightly more plants than the other two treatments (organic BASIC, 34,000 plants per acre [ppa]; non-organic BASIC, 41,000 ppa; conventional, 55,000 ppa), thereby stratifying the treatments even further in terms of density.

In-season plant development. With these density differences in mind, there appeared to be no notable treatment difference in any of the per-plant parameters measured through the season (height, number of nodes, number of vegetative nodes, number of fruiting branches, time to cutout [measured as nodes above white flower], and retention of the top five and bottom five positions [Fig. 1a - 1g; bars show one standard error of the mean]).

Early yield estimates. For the final in-season plant map, we measured several additional parameters in order to make early yield estimates. For these measures we separated the organic BASIC component from the full compliment of BASIC fields. Total first position bolls per plant (Fig. 2a) did not differ among the treatments. Total bolls (in all positions) per plant (Fig. 2b) did differ among treatments. However, because of the differences in treatment planting densities the projected number of bolls per acre (Fig. 2c) does not appear to have differed significantly. When the number of bolls per acre is extrapolated to yields per acre (Fig. 2d), no significant yield differences are apparent.

The above extrapolation is not normally done for cotton yield predictions, as per-boll lint weights can be highly variable. Indeed, our yield analysis conducted as part of the final plant sampling gave results quite different from the estimates (Fig. 2e). As a whole, the BASIC treatment produced yields significantly lower than those of the conventional treatment (BASIC = 2.00 bales/acre, conventional = 2.69 bales per acre, $p = 0.001$). Within the BASIC treatment, the non-organic field yields (2.36 bales/acre) were not significantly different from conventional yields ($p = 0.389$), while the organic field yields (1.7 bales/acre) were lower than conventional yields ($p = 0.001$). When end-of-season plant density was included as a covariate, the overall BASIC treatment yield did not differ from the average conventional yield, but the organic yield remained significantly lower than conventional yield ($p = 0.025$).

(Note: The use of planting density rather than harvest density decreased the predictive ability of our original calculations in our study, in which there was differential plant density loss among treatments during the season. It is likely that, had we been able to use harvest plant density or an approximation -- by re-measuring plant density near the end of the season -- yield predictions would have been quite a bit more accurate).

End-of-season plant measurements. In addition to yield estimation, at the end of the season we analyzed treatment differences in final plant height; number of nodes, vegetative nodes, and fruiting branches; bottom five position retention; and number of first position, second position, and other "outer position" bolls per plant (Figures 2f - 2k). Although statistical analyses have not yet been done on most of these, there are some notable treatment differences. First, numbers of vegetative and fruiting branches are somewhat lower in the conventional treatment, (also, height to node ratio is smaller in non-organic BASIC). Second, within the BASIC treatment there are fewer first position and more outer position (second, third, and other) bolls on each plant than within the conventional treatment (Fig. 2k). On a per-acre basis (Fig. 2l), however, boll production at all positions, including outer ones, is lower in the BASIC treatment. However, when analyzed using density as a covariate, none of these boll position differences is significant. In many cases boll position fairly strongly correlates with density within each treatment; e.g. Figures 2m - 2n. These boll position results differ from those of previous years, in which outer position boll production was significantly greater in the organic BASIC treatment, and was high enough to make up for low plant densities in overall yield production. The absence of large numbers of outer position bolls may be related to the early cutout date which occurred in 1997 (August 1 - 4; see Figure 1e).

Gin-based yields and lint quality. We verified yield estimates with gin records, when available. We also used these records to compare lint turnout percentages and several measures of lint quality (staple length, strength, and micronaire; leaf content; and color grade distribution). We obtained gin records for eight of the BASIC fields, and three of the check fields (with partial records, showing yields and turnouts only, obtained from a fourth check field). We plan to obtain gin records for one additional BASIC and check field at the time of the interviews for the 1997 field season. We will not be able to obtain records for the remaining 1996 check fields.

A comparison of 1996 yields based on gin records and hand-harvested estimates is shown in Figure 2p. For the BASIC and LDO fields, our estimates were all within about 10% or less of gin-based yields. For check (conventional) fields, our estimates were about 18% lower than gin-based yields (perhaps because we did not have all of the check field gin records). Based on gin records, BASIC and LDO yields did not differ from each other, but were lower than conventional yields by about 2/3 of a bale. Average turnouts were slightly higher in conventional fields than in BASIC and LDO fields (Figure 2q).

Of the three measures of intrinsic fiber properties (staple length, fiber strength, and micronaire), only micronaire differed between the 1996 treatments (Figure 2r); however, micronaire values did not cause fiber discounting in any of the treatments. Both staple length and fiber strength in all treatments were optimal. There was little overall difference in 1996 color grades between either conventional and BASIC (Figure 2s) or conventional and the LDO subset of BASIC (Figure 2t). Leaf content (Figure 2v) also did not differ greatly between treatments. Leaf content for conventional fields, while higher than we have seen in prior years, was slightly lower than those for BASIC or LDO. In prior years' comparisons between organic and conventional fields, we have seen greater treatment differences between these two measures of cotton quality. Overall similarities between the treatments in 1996 resulted from improvements in the organic fields as well as quality decreases in the conventional fields. High leaf content values and variable color grades in conventional fields may have resulted from lower than optimum plant desiccation and defoliation.

Insect Populations

Sweep net samples. We conducted weekly sweep samples (four 50-sweep samples per treatment replicate) for lygus bugs and natural enemies. Early season *Lygus* populations this year were low in both BASIC and check fields (Fig. 3a), and were similar between the two throughout the season except for one date in early August, when BASIC fields had more *Lygus* than did check fields. However, at that point in August plants were beyond the peak squaring period which is the critical period of *Lygus* damage. Lygus nymph populations were similar in both BASIC and check fields (Fig. 3b).

1997 sweep samples were similar to 1996 data, in showing a consistent trend of higher natural enemy (predator) populations in BASIC treatment fields than check fields (Fig. 4a). This difference, again similar to 1996, is mainly due to *Geocoris* spp. abundances (Fig. 4b). The second most common natural enemy, *Orius tristicolor*, appeared in similar densities in both treatments (Fig. 4c). Although they have been released through the season in BASIC fields, lacewings abundances have been low in our samples (Fig. 4d). Other natural enemies, including ladybird beetles (Fig. 4e), damsel bugs (Fig. 4f), assassin bugs (Fig. 4g), and spiders (Fig. 4h), have been present in small and highly varying numbers this year, and we have found no trends in their population abundances. Total juvenile predator numbers (Figure 4i) were slightly higher in BASIC fields, especially towards the end of the season.

Leaf samples. Leaf samples showed larger early season spider mite populations in BASIC treatment fields than in check fields. Figure 5a shows percent of leaves infested with mites, while Figure 5b shows the average mite rank in each treatment. Mite rank is a log scale, with rank of 1 corresponding to zero mites and 2 corresponding to 1 to 10 mites per leaf. Although up to thirty percent of leaves in the fields were infested with mites, the actual mite populations on those leaves remained very small, at less than five per leaf. Populations of western flower thrips, a mite predator which can also cause plant damage, were also low throughout the season, and were slightly higher in the BASIC than in the check fields (Fig. 5c). Aphid populations (Fig. 5d), have remained low this year and did not differ between treatments.

Flame Weeding Experiments

We conducted two flame weeding trials, one to test the effects of flame weeding on weed control in mid-season cotton (~20 in. high), and the second to examine the impacts of flame weeding on pest and beneficial insect populations. In the flame treatment, twelve rows were flamed using a six-row flamer. The flame treatment and unflamed control were replicated four times. Although the final results are not yet available from Dr. Prather, flame weeding in fields of moderate field bindweed density appeared to substantially reduce bindweed stem numbers. Flaming in areas of low or very high bindweed densities had less of an effect. Flaming also appeared to have a strong effect on bermuda grass vigor, but less of an effect on johnsongrass. Full results will be included in the next progress report.

The same experimental design was used in the second experiment. Four 50-sweep samples with a 15-inch net were taken in each replicate. Samples were taken four times: immediately prior to flaming, immediately post-flaming, 24 hours post-flaming, and one week post-flaming. There were statistically significant immediate post-flame decreases in *Lygus* numbers (Fig. 6a), total natural enemy numbers (Fig. 6b), and juvenile natural enemy numbers (Fig. 6c), as well as more lasting effects on some of these insects, including bigeyed bugs (Fig. 6d). Populations of minute pirate bugs (Fig. 6e) and ladybird beetles (Fig. 6e) (which, with bigeyed bugs, make up the three most common natural enemies found in the experiment) were not significantly impacted. We plan to repeat and expand this experiment in the next production season.

Operational Costs of Production

Table 1 in Appendix A shows average 1996 operational costs of BASIC and participating conventional growers. As with the yield results, these data are not yet quite complete due to the two additional gin record sets we hope to obtain in the near future. (Because of this, yields in Table 1 differ slightly from yields shown in Figure 2p). There was high variability between individual growers and/or fields; therefore, economic differences between BASIC and conventional fields will most likely not be statistically significant. The general trend showed that BASIC growers had lower total operational costs per acre than did the conventional growers. However, BASIC growers had lower yields, resulting in a higher average cost per bale for BASIC growers. It is possible that later planting dates on several of the BASIC fields (late April - early May) contributed to these lower yields. In 1997 all BASIC enrolled and check fields were planted by mid-April, to avoid this confounding influence. Specific production differences between BASIC and conventional check fields were: (a) lower cultural field power and materials costs for BASIC growers, mainly due to decreased chemical applications; (b) higher cultural custom/rental costs for some BASIC growers, mainly due to increased hand-weeding costs; and (c) increased harvest costs for BASIC growers, some of whom harvested a second time.

Separating the BASIC fields into sub-categories revealed several interesting trends. Costs per bale were lowest, and closest to conventional costs, in the non-organic BASIC fields. Yield losses in the non-organic BASIC fields were offset by low per-acre production costs (fewer chemical applications than conventional growers, and fewer hand- and machine-weeding operations than organic growers). The LDO (low plant density organic; 20-30,000 plants per acre) fields had somewhat higher costs per bale, and costs per bale were highest in the organic group taken as a whole. In both cases (LDO and all organic fields), higher costs per bale resulted from production costs which were larger than those of non-organic BASIC, and yields which were lower than those for conventional. Cultural materials costs were 40% lower for LDO than for conventional, while cultural custom/rentals costs were 44% higher. Harvest costs were higher for LDO, due to multiple harvest runs.

Although the non-organic BASIC fields were closest to conventional fields in operational costs per bale, costs were still on average $20 per bale higher than those of conventional fields. For this production strategy to be economically viable, either per-acre costs must decrease or yields must increase. For the organic BASIC fields the situation differs in that certified organic cotton receives a price premium. The economic viability of these organic fields depends on the size of that price premium.

Reporting on energy analyses has been postponed to a 1998 progress report.

Figure 1a.
1997 BASIC Plant Maps
height

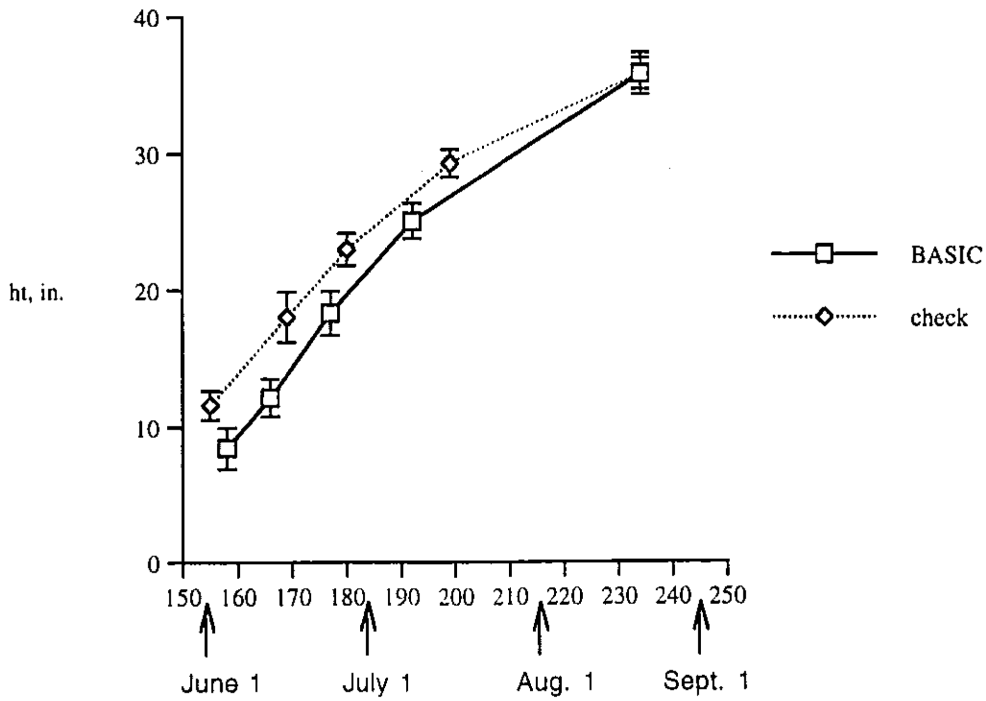

Figure 1b.
1997 BASIC Plant Maps
nodes

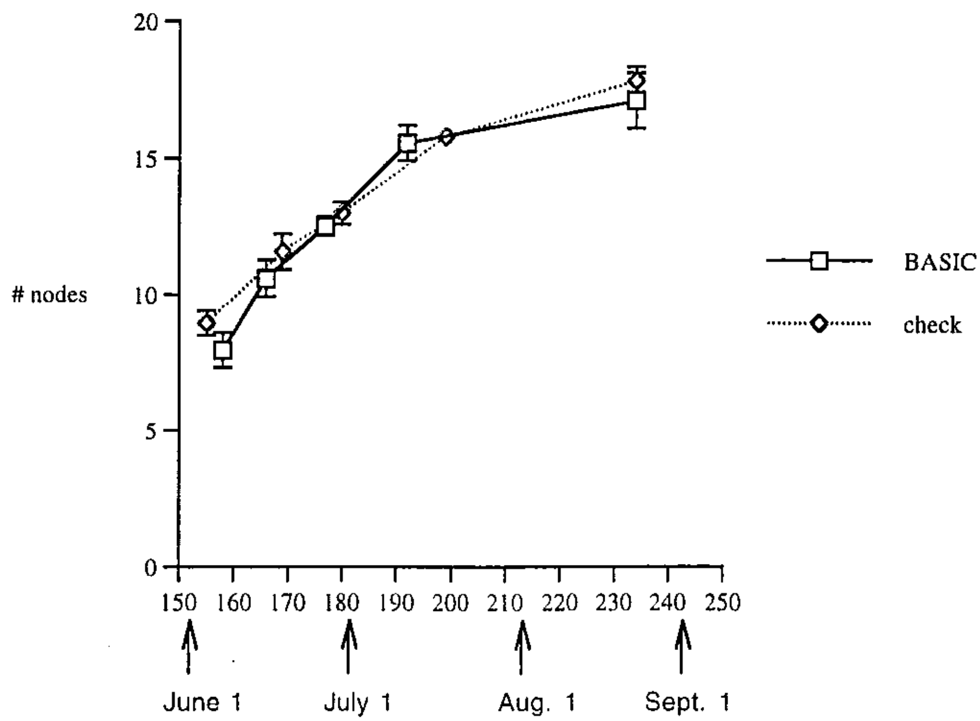

Figure 1c.
1997 BASIC Plant Maps
vegetative nodes

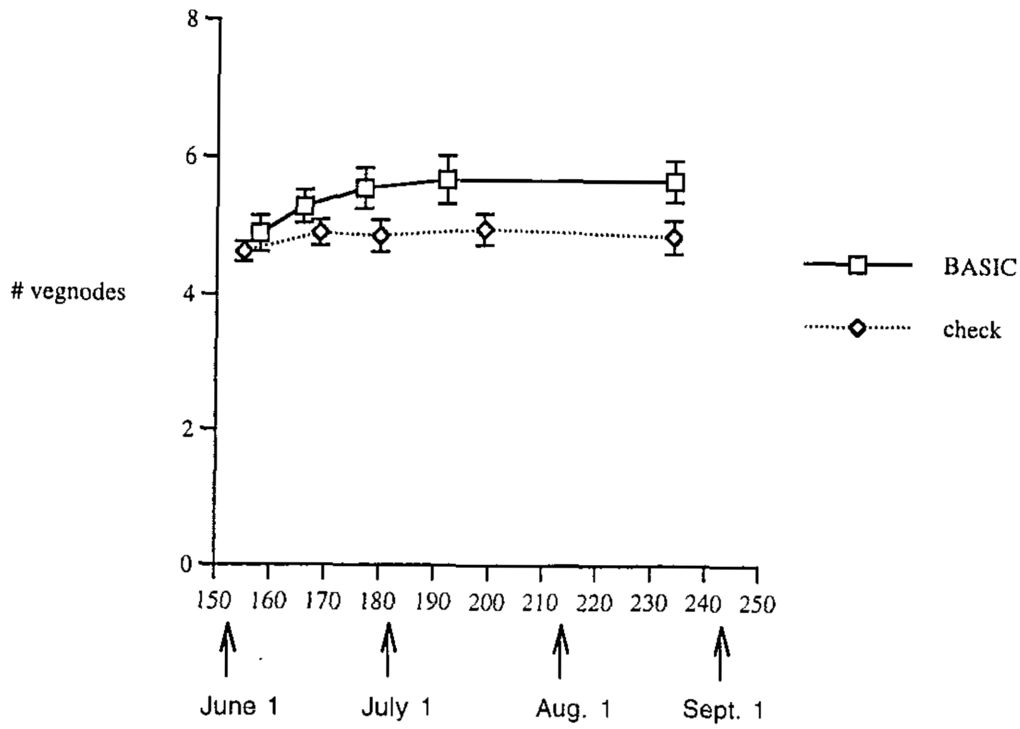

Figure 1d.
1997 BASIC Plant Maps
Fruiting branches

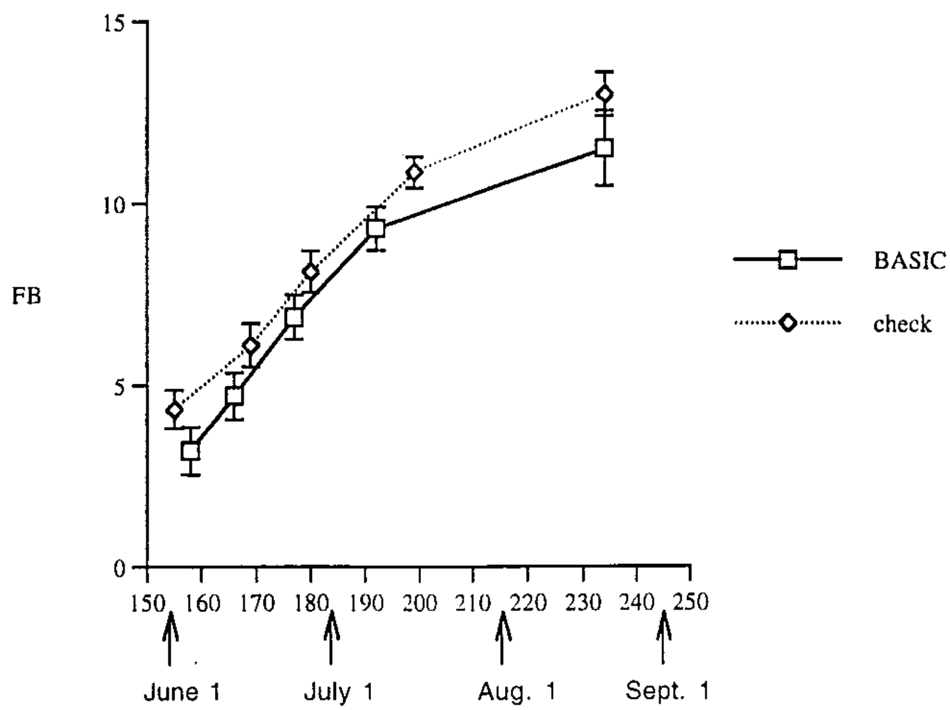

Figure 1e.
1997 BASIC Plant Maps
Nodes above white
flower

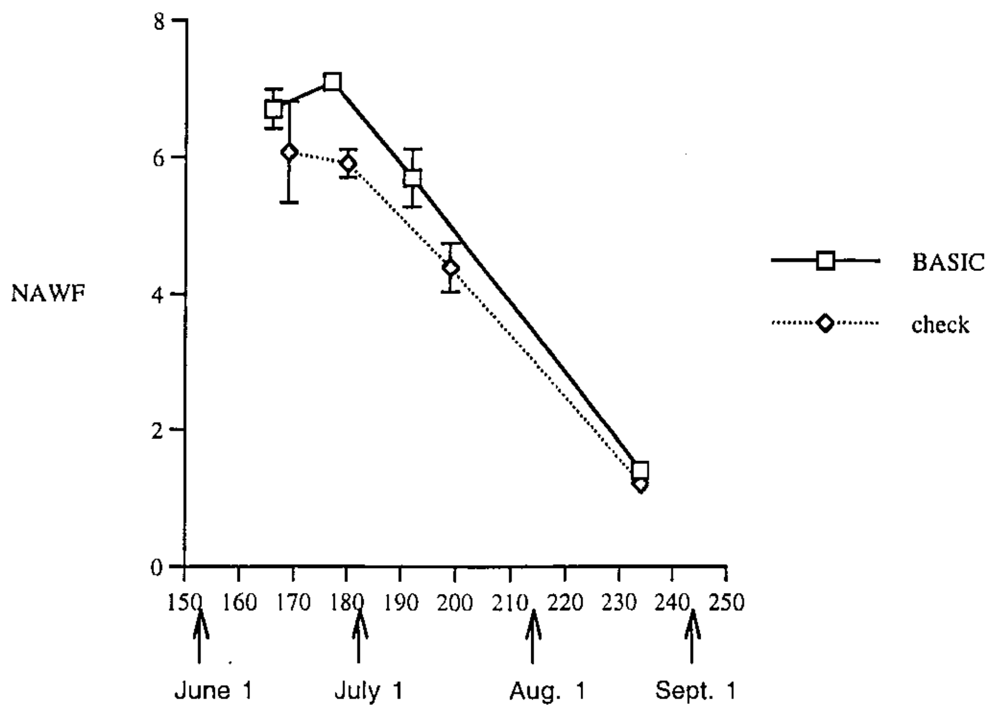

Figure 1f.
1997 BASIC Plant Maps
top 5 retention

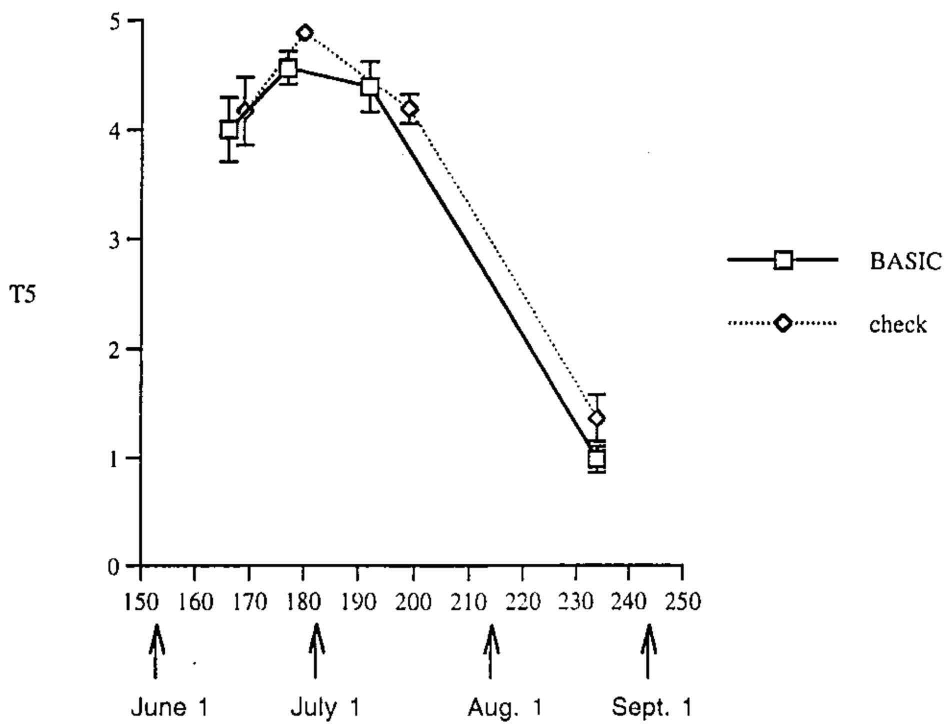

Figure 1g.
1997 BASIC Plant Maps
bottom 5 retention

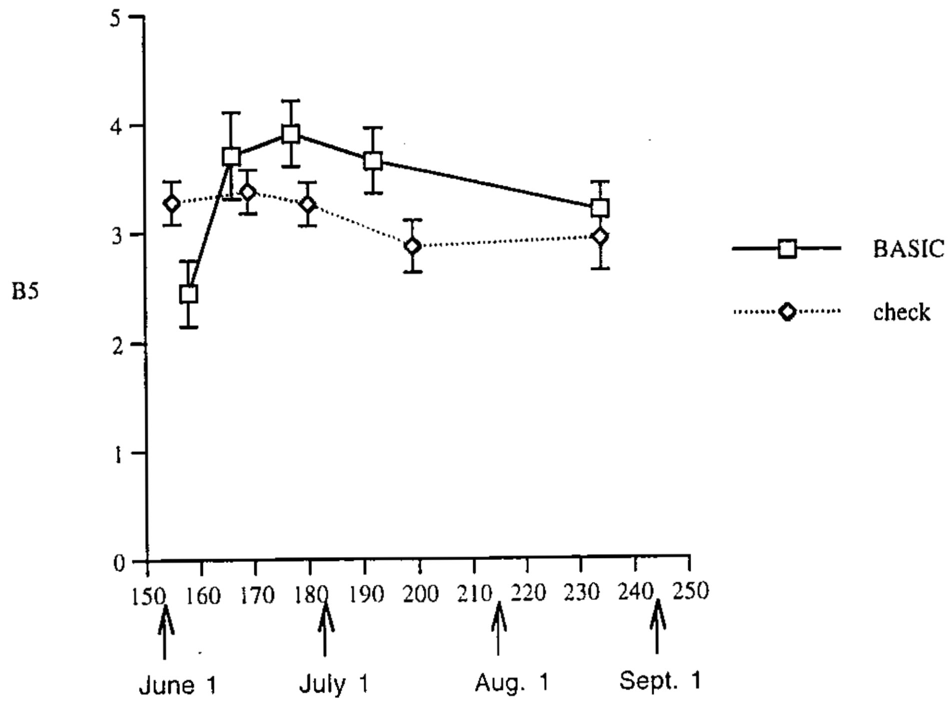

Figure 2a.
1997 BASIC
First Position Bolls Per Plant

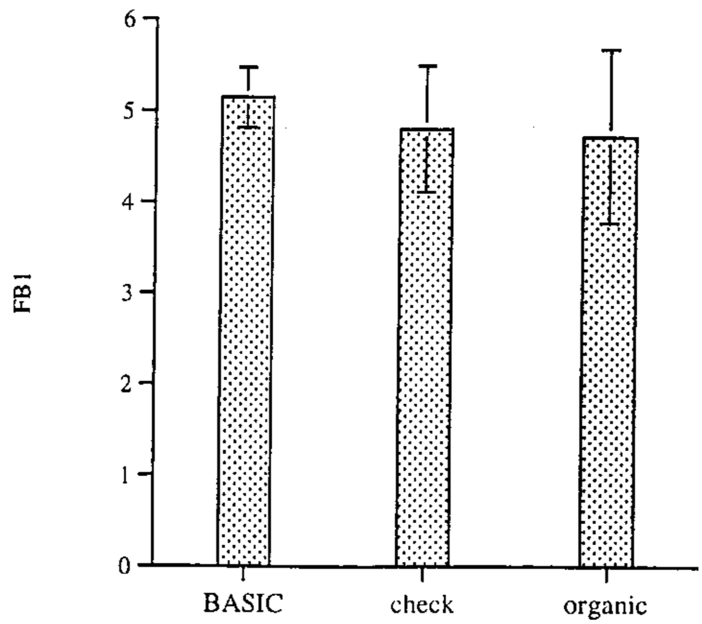

Figure 2b.
1997 BASIC
Total Bolls Per Plant

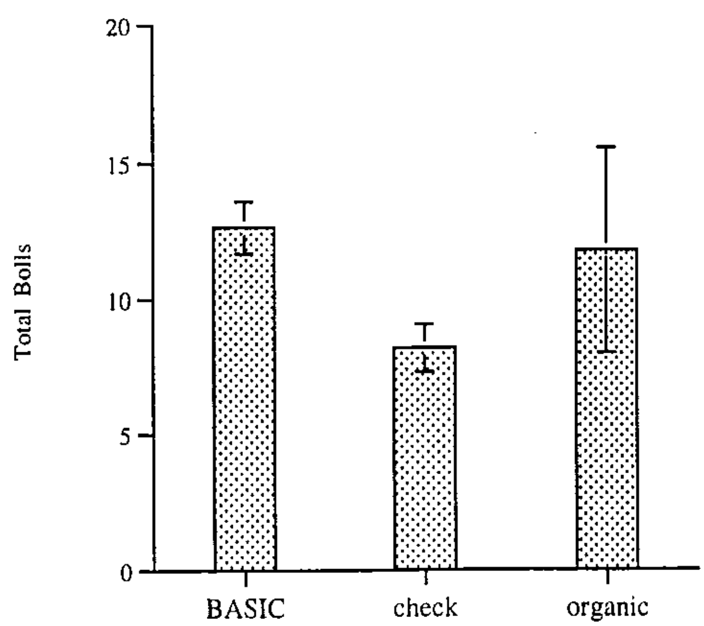

Figure 2c.
1997 BASIC
Projected Bolls Per Acre

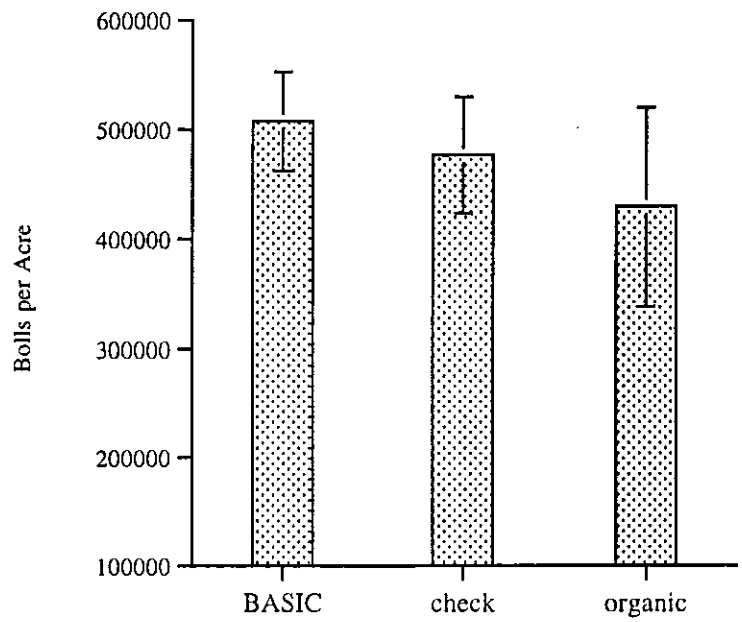

Figure 2d.
1997 BASIC
Projected yields,
bales/acre

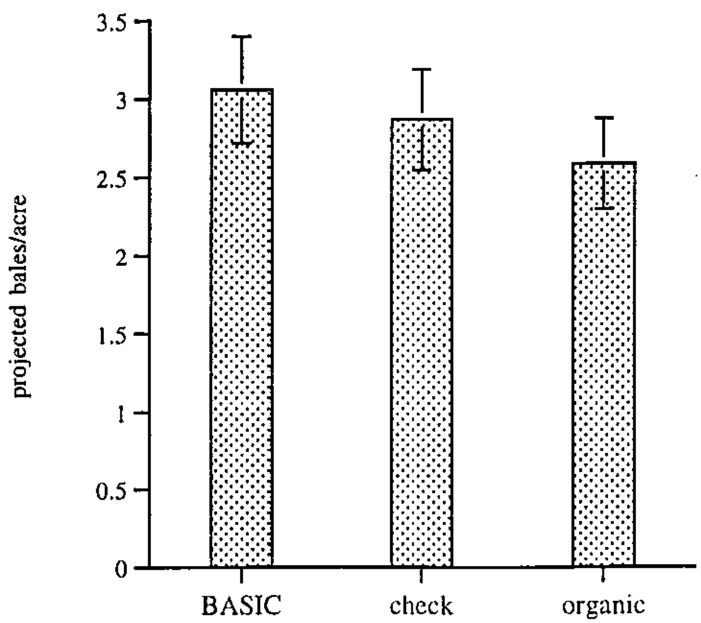

Figure 2e. 1997 BASIC
Yields and plant density

Values are averages ±1 S.E.M. Values labelled with different letters are significantly different (ANOVA, $p < 0.05$; Tukey HSD for post-hoc analyses; yield analysis done using density as a covariate).

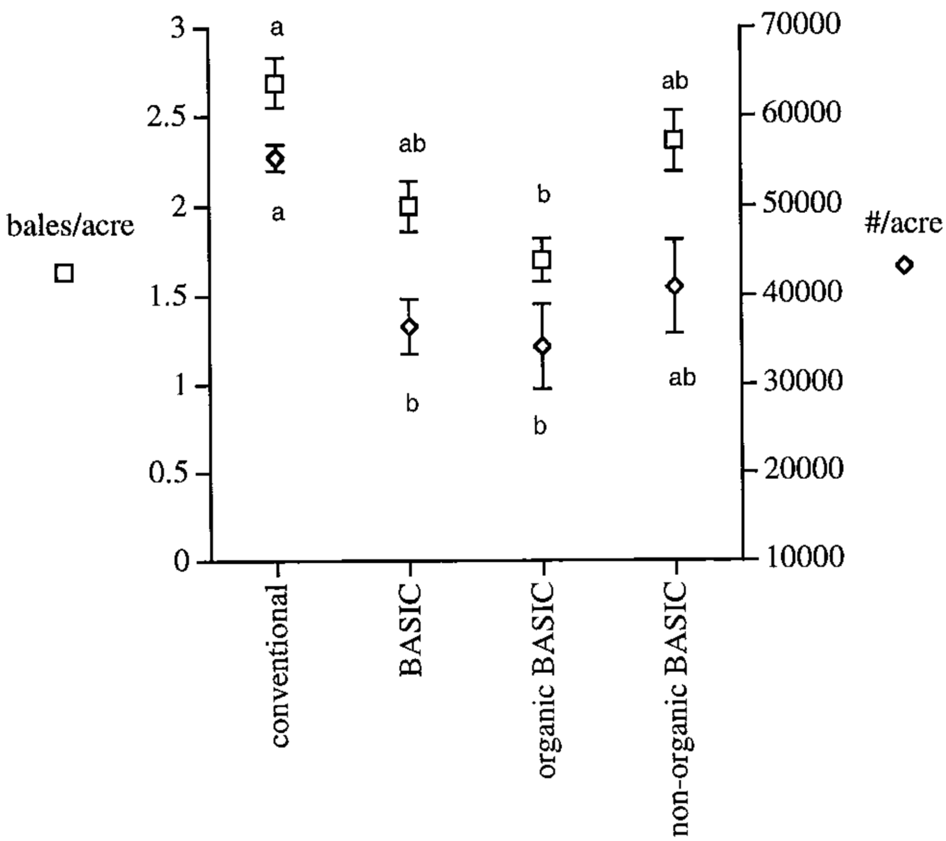

Figure 2f. 1997 BASIC
Final plant height

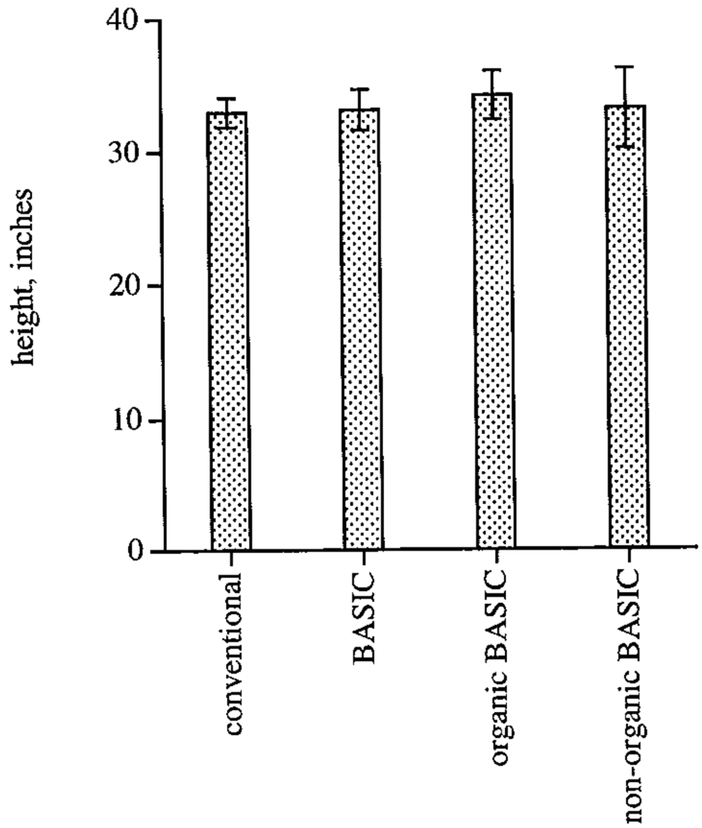

Figure 2g. 1997 BASIC
Final # nodes

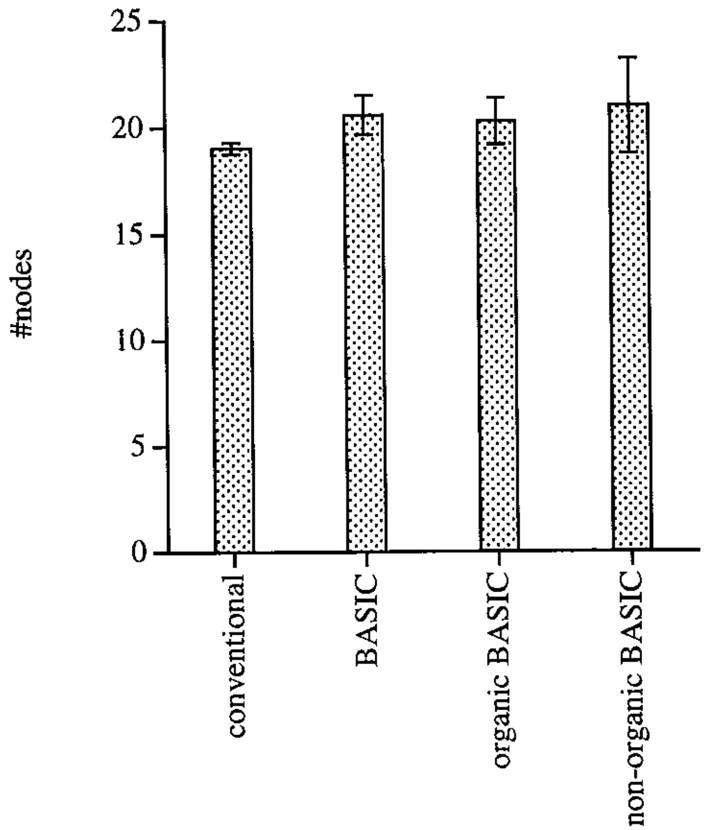

Figure 2h. 1997 BASIC
vegetative nodes

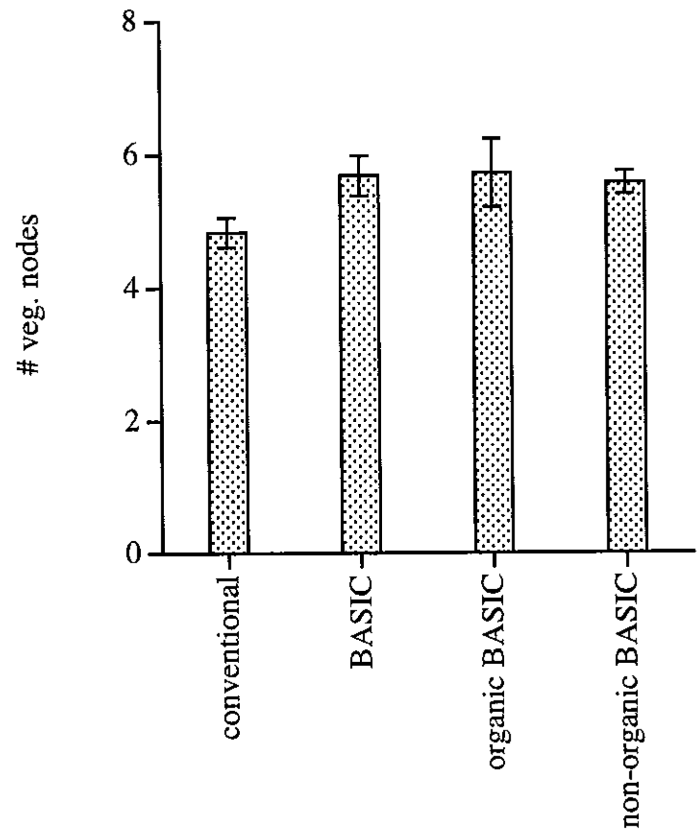

Figure 2i. 1997 BASIC
Final # fruiting branches

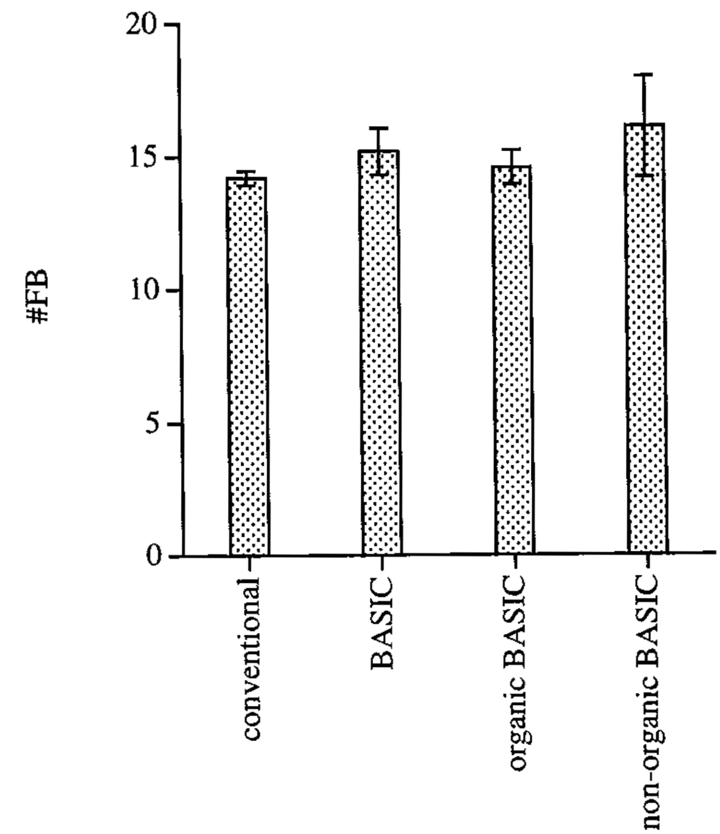

Figure 2j. 1997 BASIC
Final bottom 5 retention

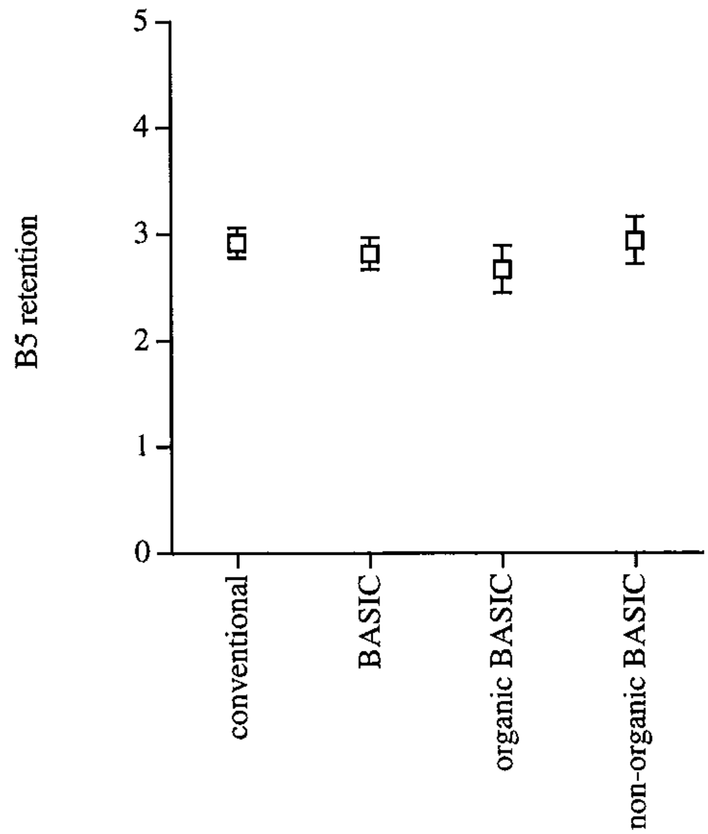

Figure 2k. 1997 BASIC
Boll production per plant

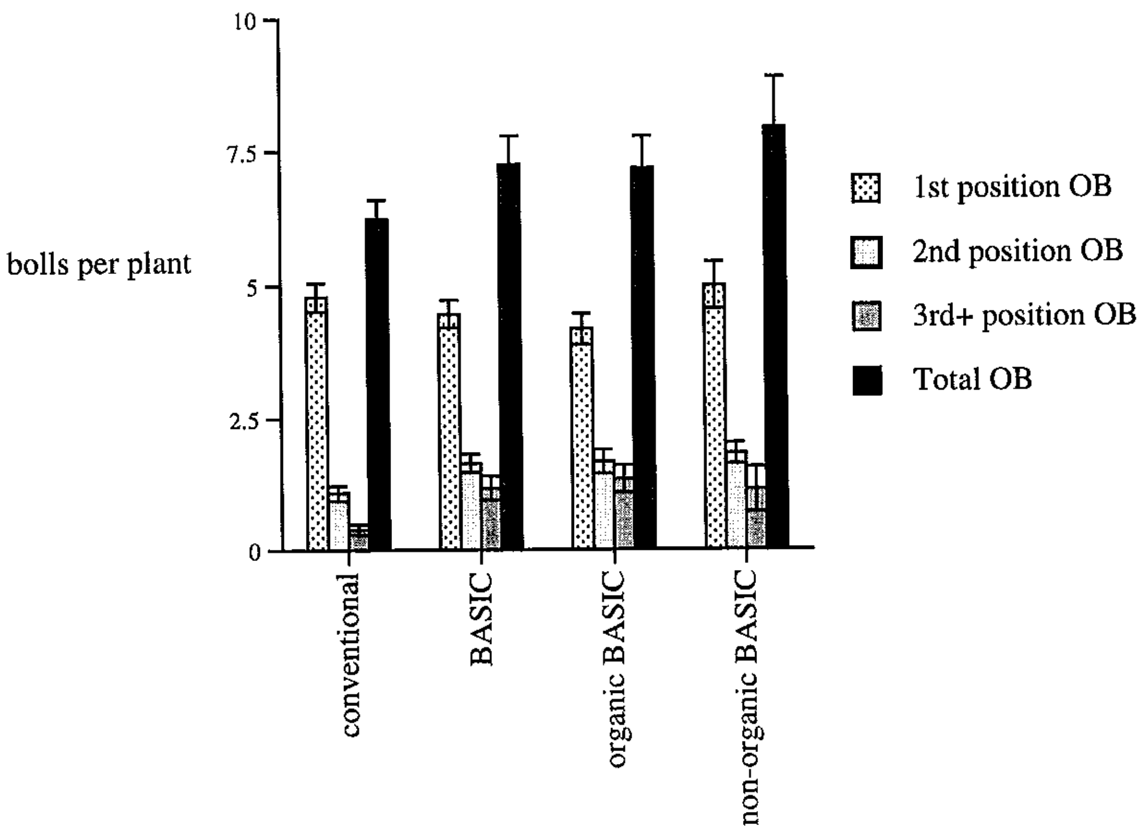

Figure 21. 1997 BASIC
Boll production per acre

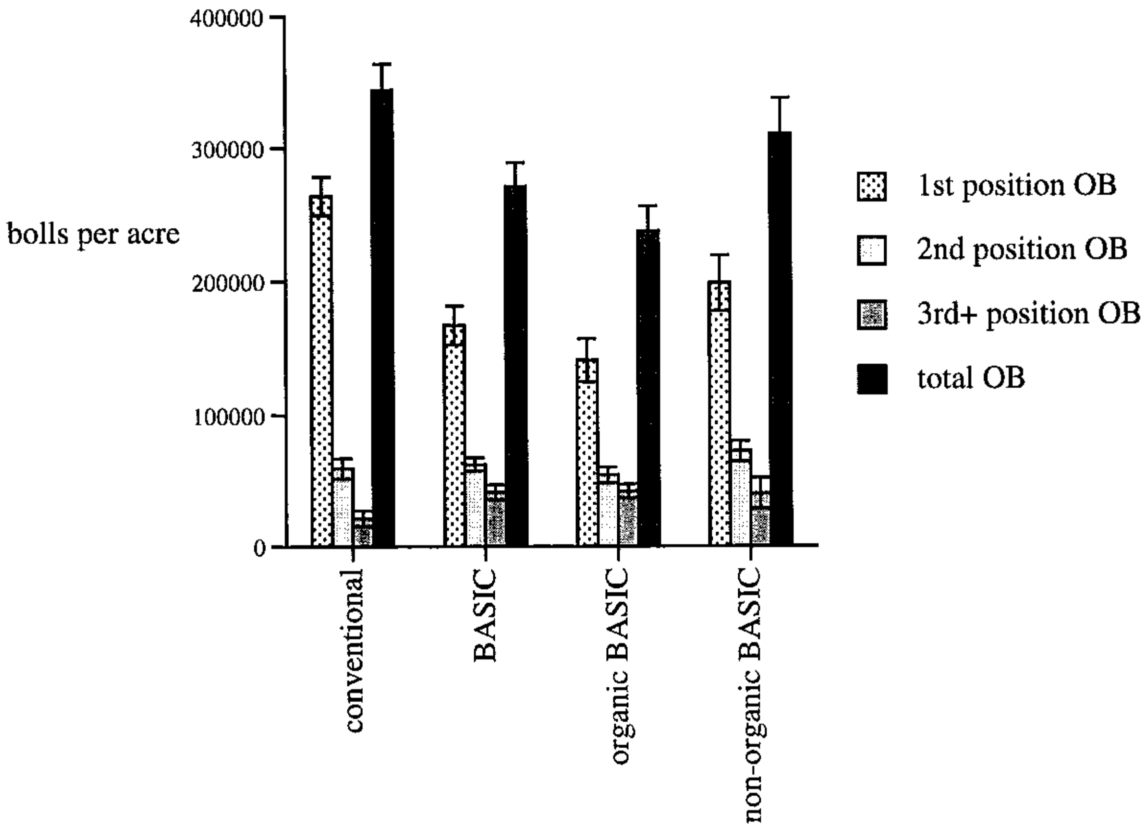

Figure 2m. 1997 BASIC
Density vs. 3rd position open bolls

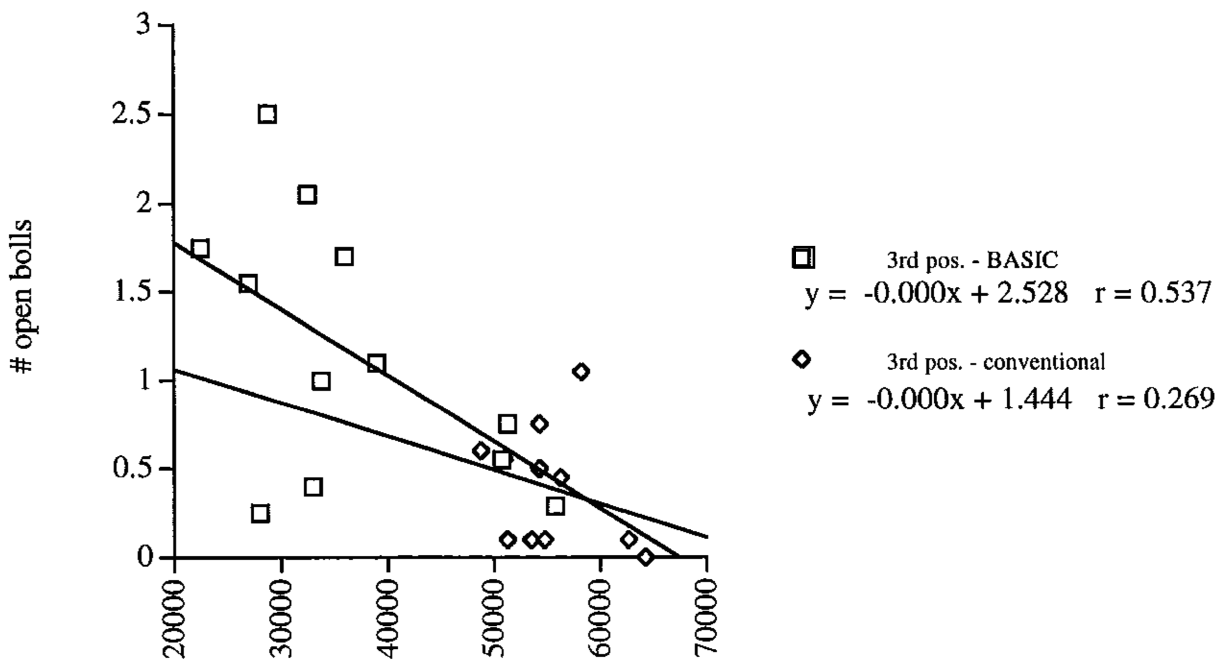

Figure 2n. 1997 BASIC
density vs. total open bolls per plant

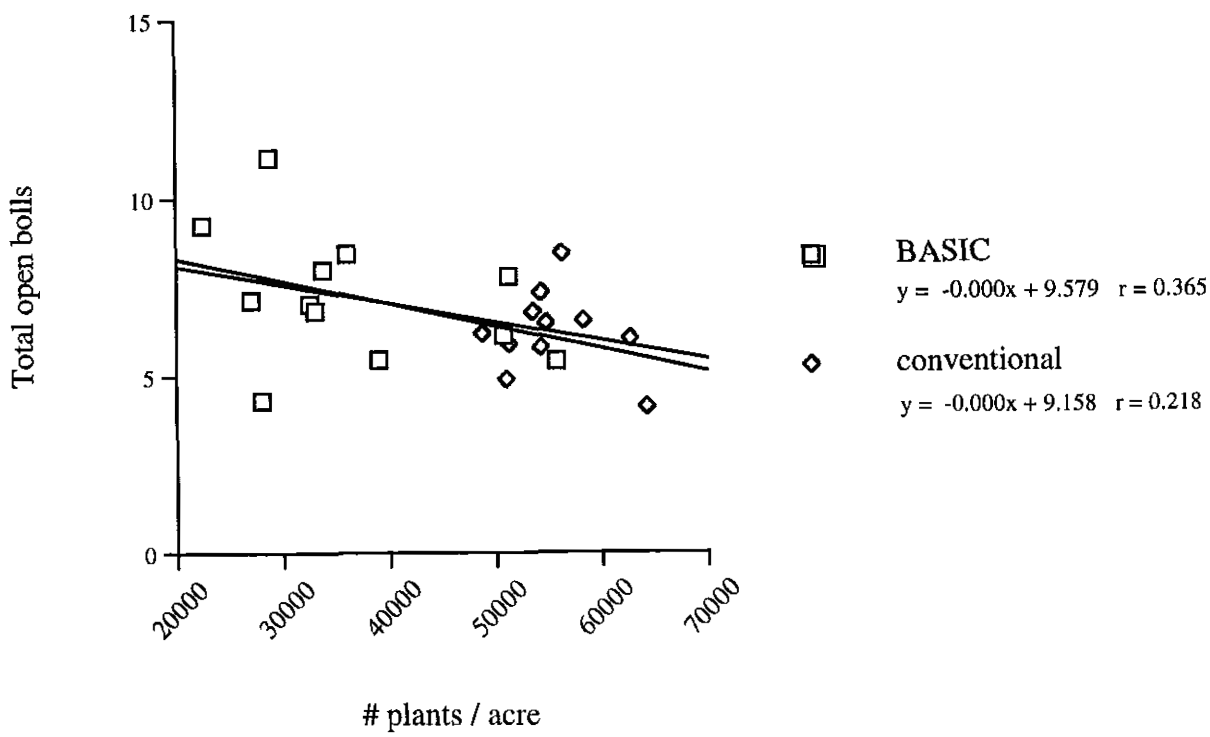

Figure 2p. 1996 BASIC yields
Comparison of gin records and
harvest yield estimates

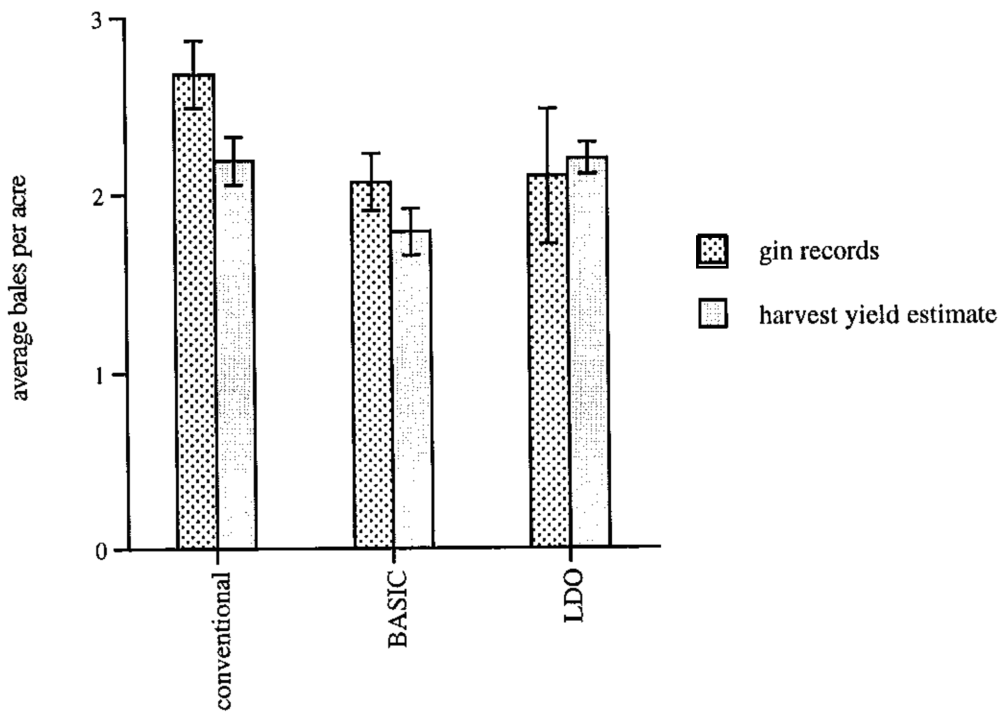

Figure 2q. 1996 BASIC gin data
Lint turnout

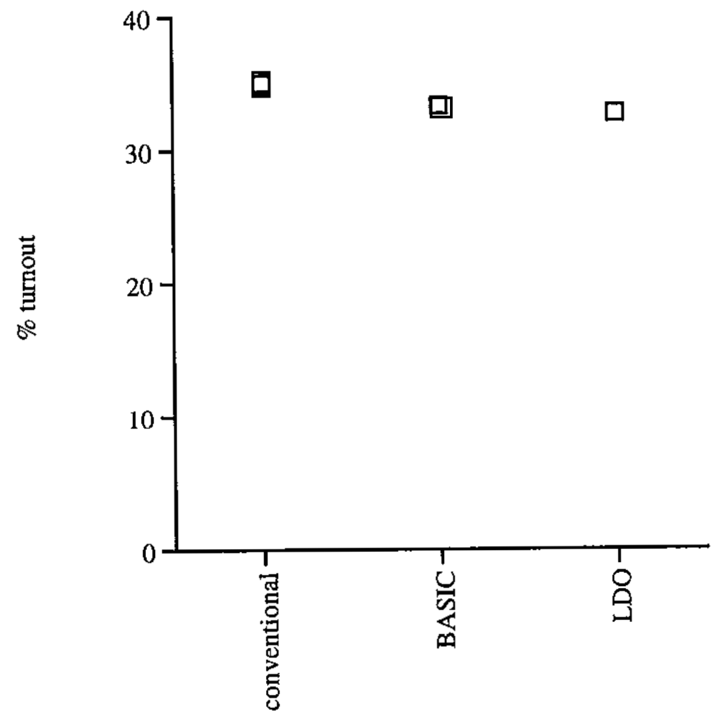

Figure 2r. 1996 BASIC gin data

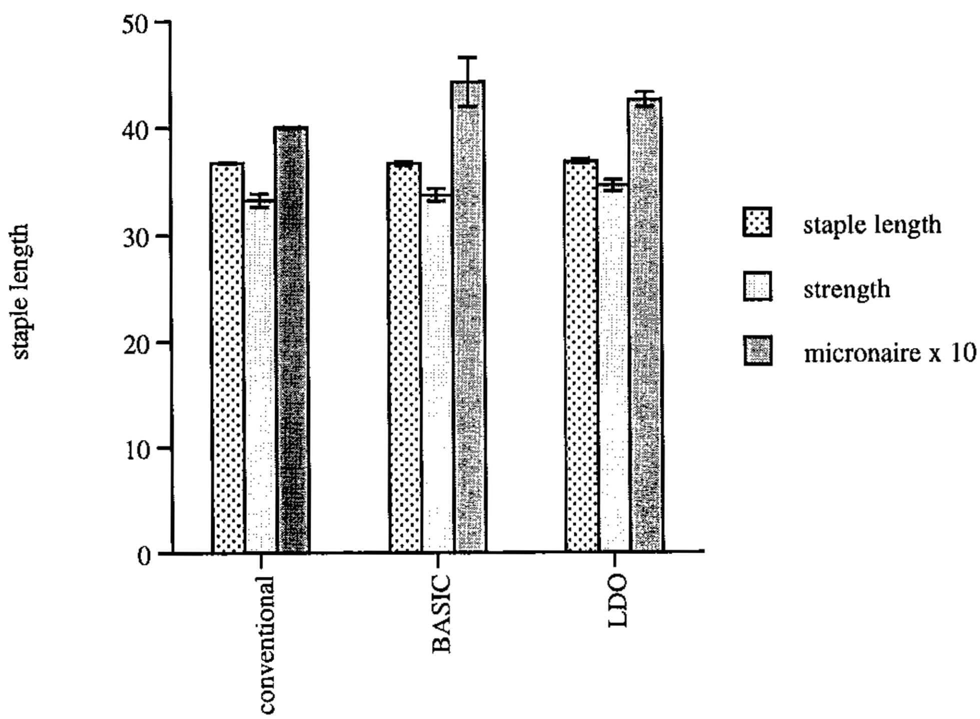

Figure 2s. 1996 BASIC gin data
color grades
Conventional and BASIC

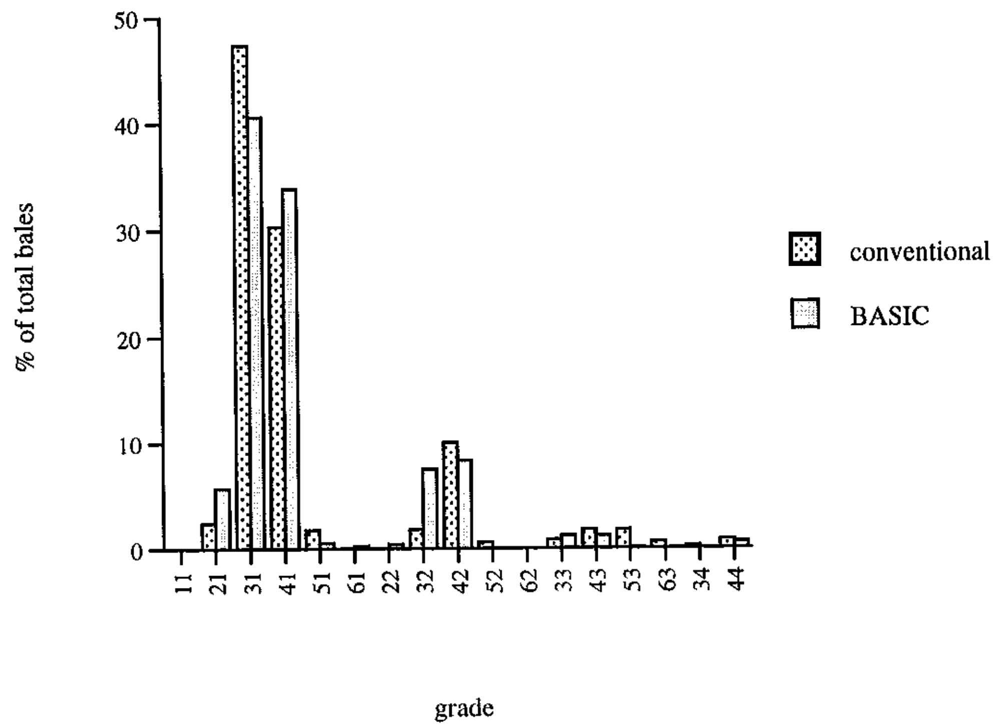

Figure 2t. 1996 BASIC gin data
color grades
Conventional and organic

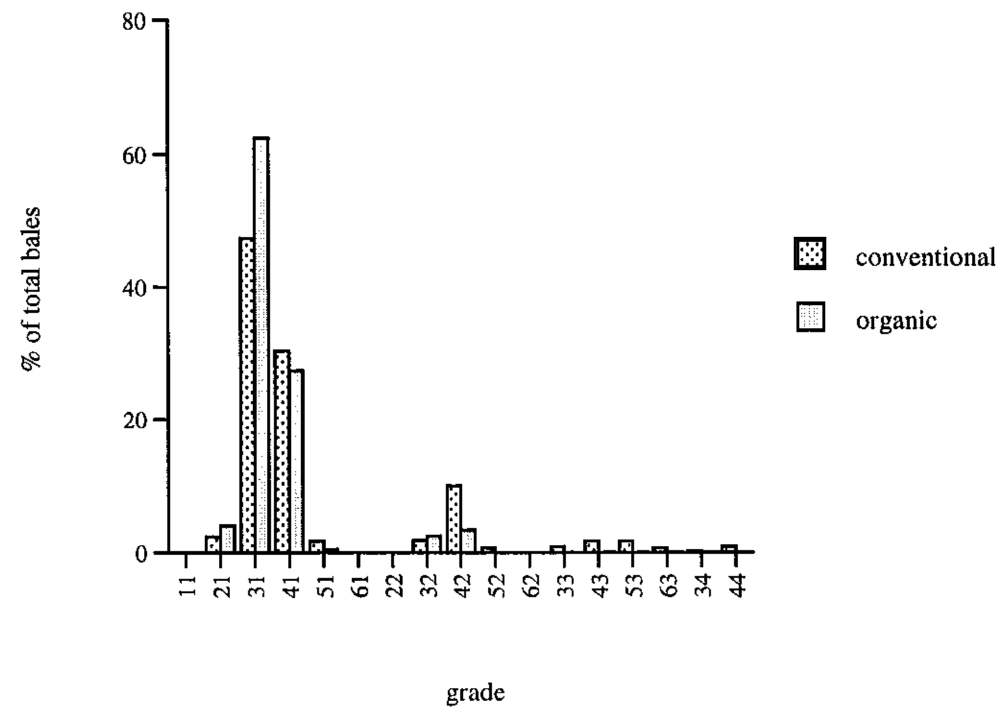

Figure 2v. 1996 BASIC gin data
Leaf content

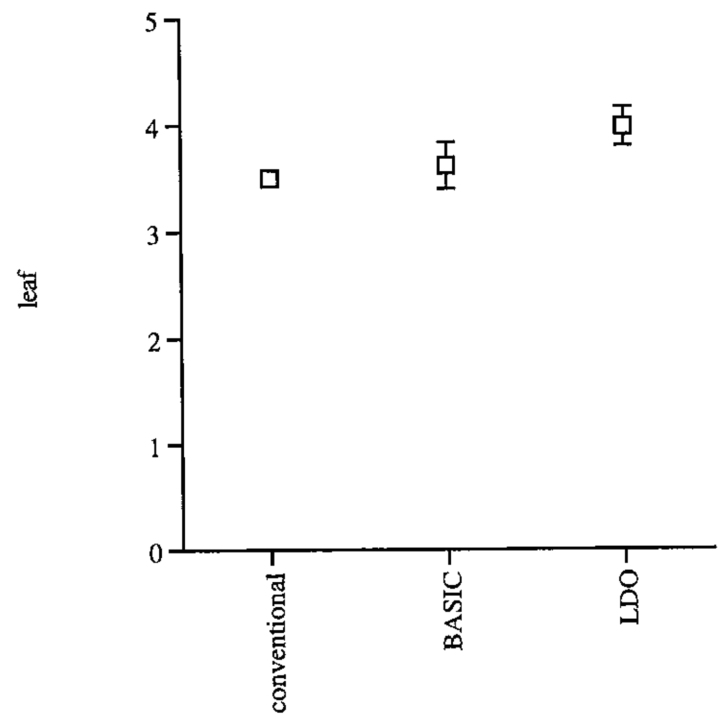

Figure 3a.
1997 BASIC sweep insects
Total Lygus

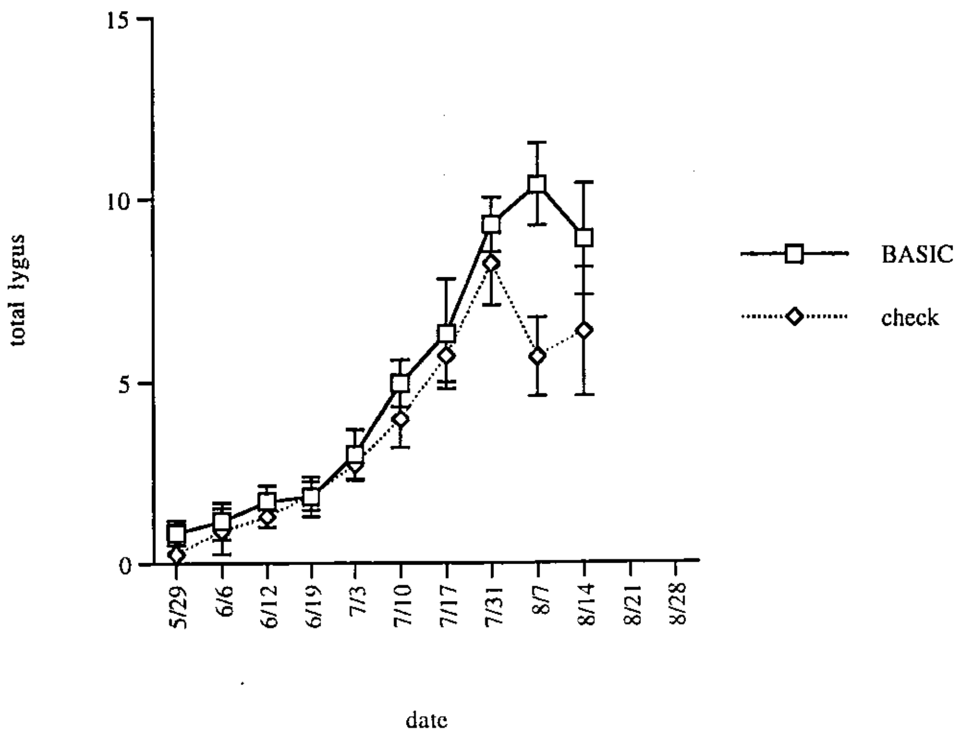

Figure 3b.
1997 BASIC sweep insects
Lygus nymphs

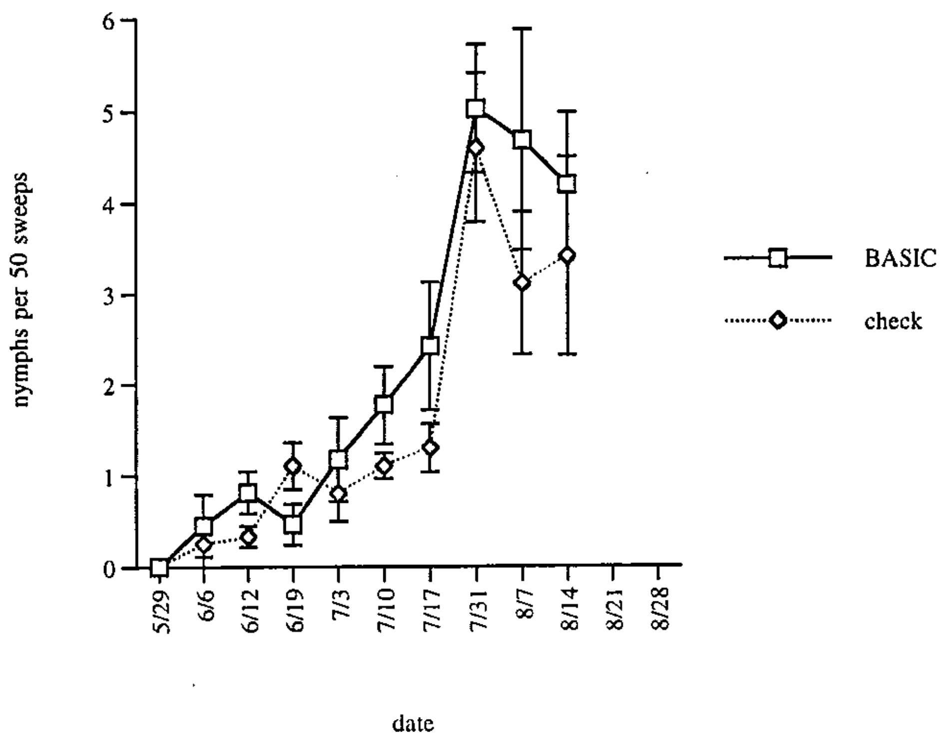

Figure 4a.
1997 BASIC sweep insects
total beneficial insects

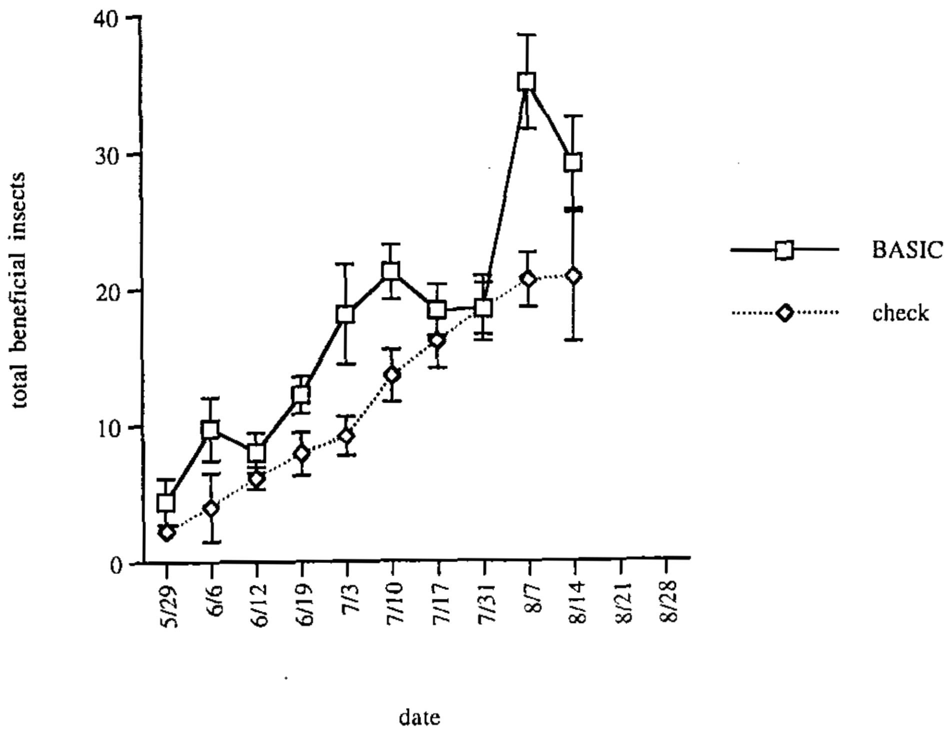

Figure 4b.
1997 BASIC sweep insects
Total bigeyed bugs

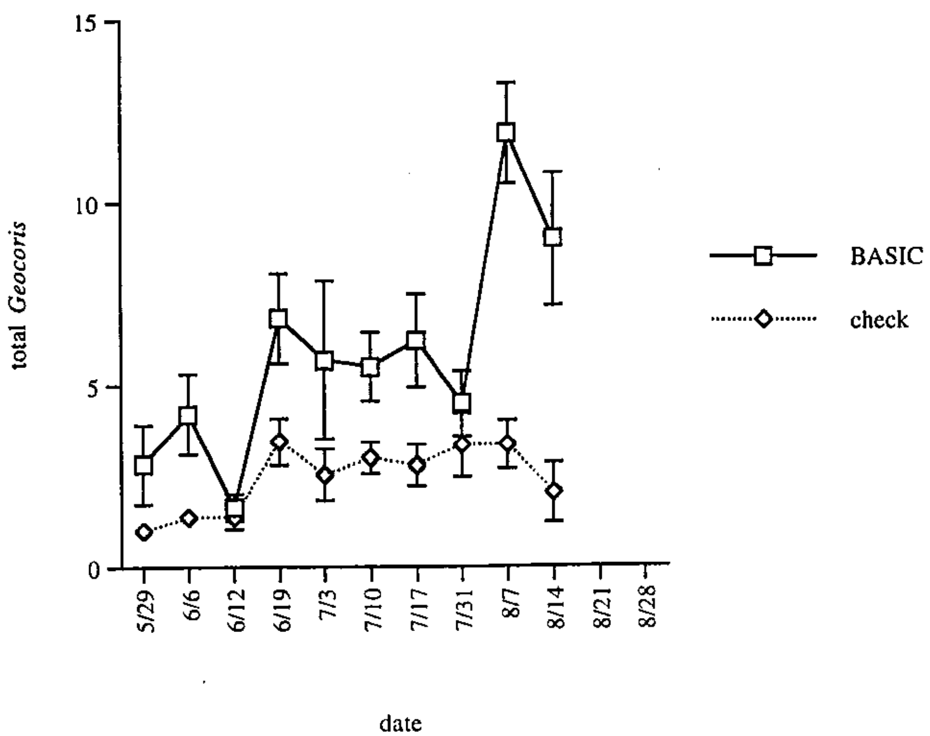

Figure 4c.
1997 BASIC sweep insects
total minute pirate bugs

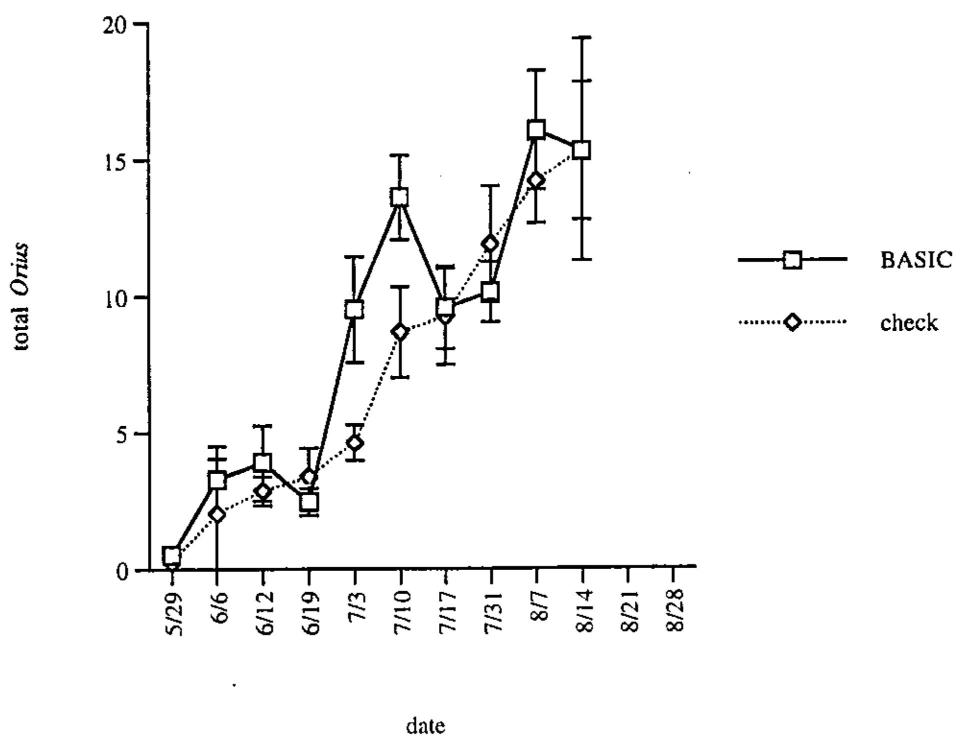

Figure 4d.
1997 BASIC sweep insects
total lacewings

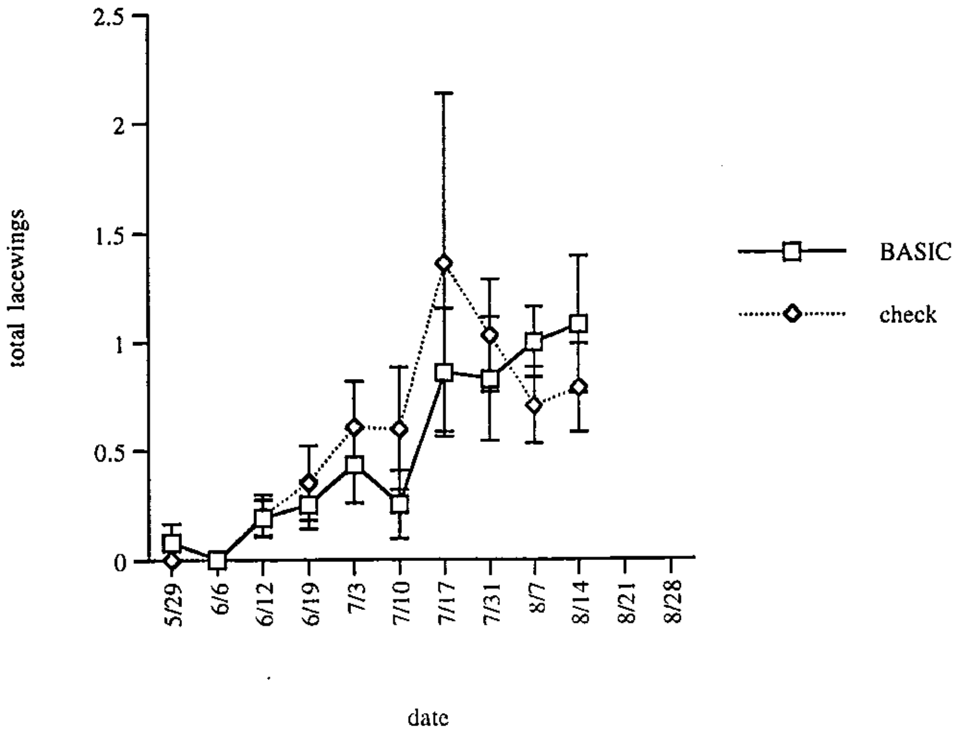

Figure 4e.
1997 BASIC sweep insects
total ladybird beetles

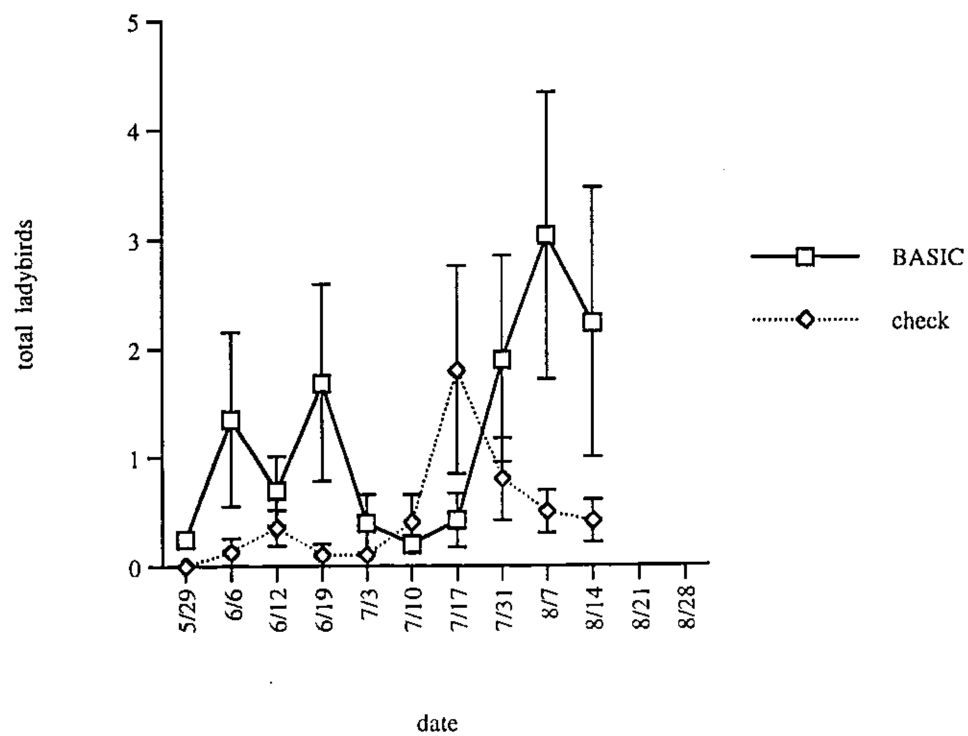

Figure 4f.
1997 BASIC sweep insects
Total damsel bugs

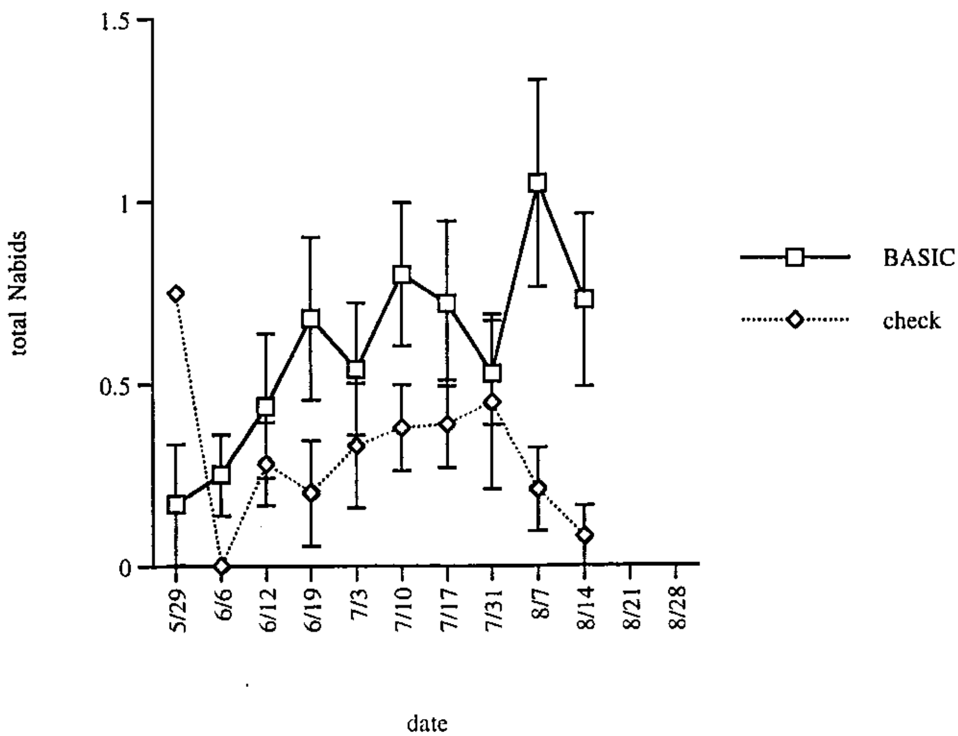

Figure 4g.
1997 BASIC sweep insects
total assassin bugs

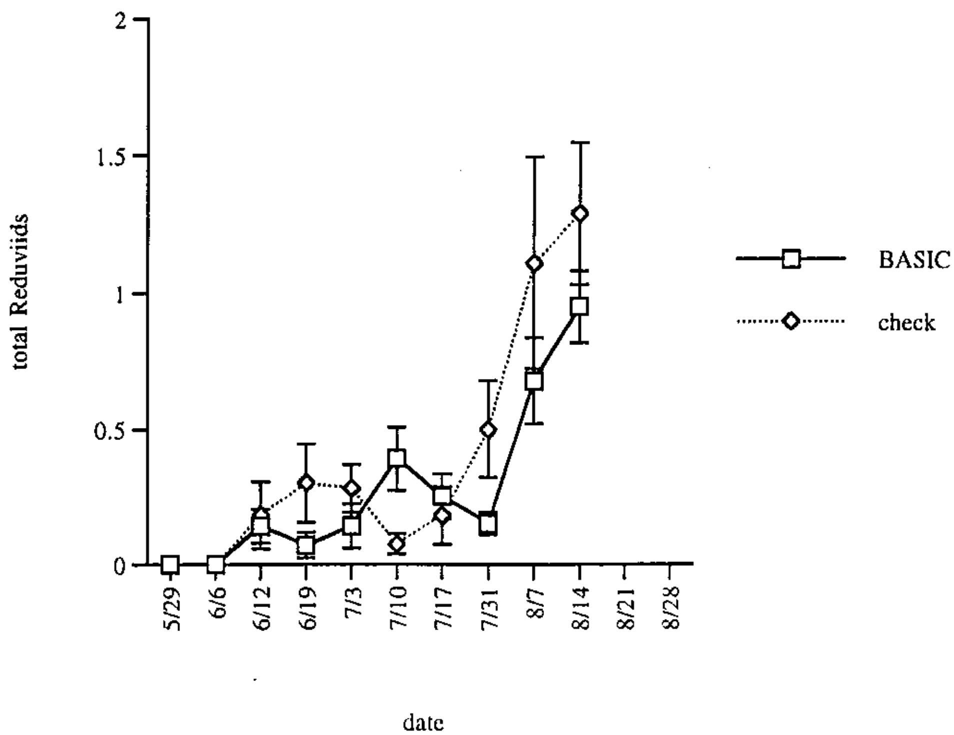

Figure 4h.
1997 BASIC sweep insects
spiders

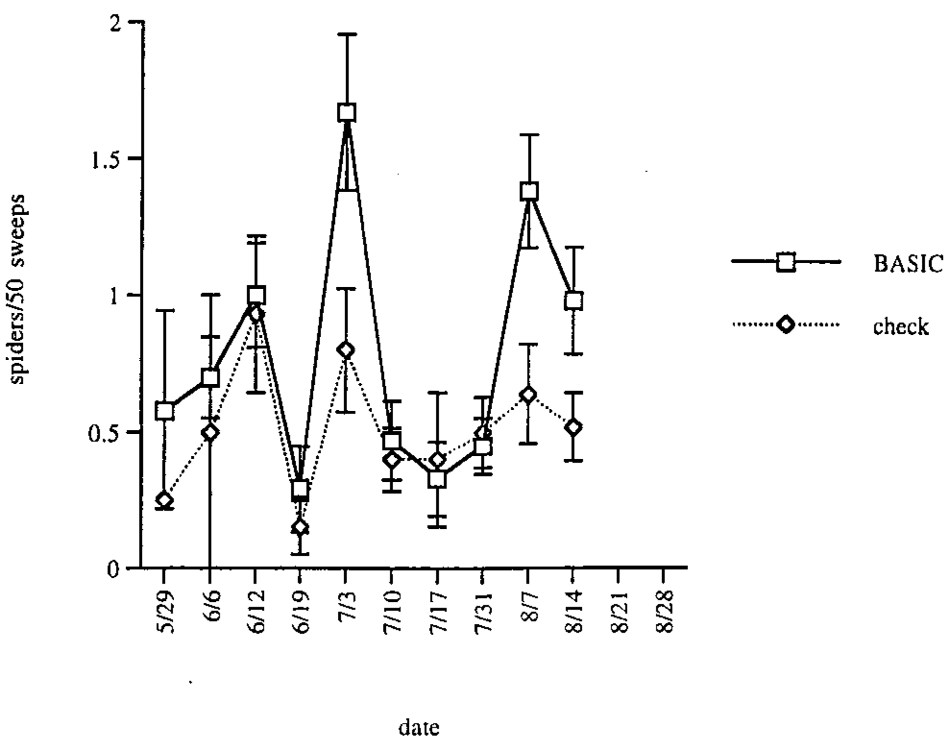

Figure 4i.
1997 BASIC sweep insects
total juvenile beneficial insects

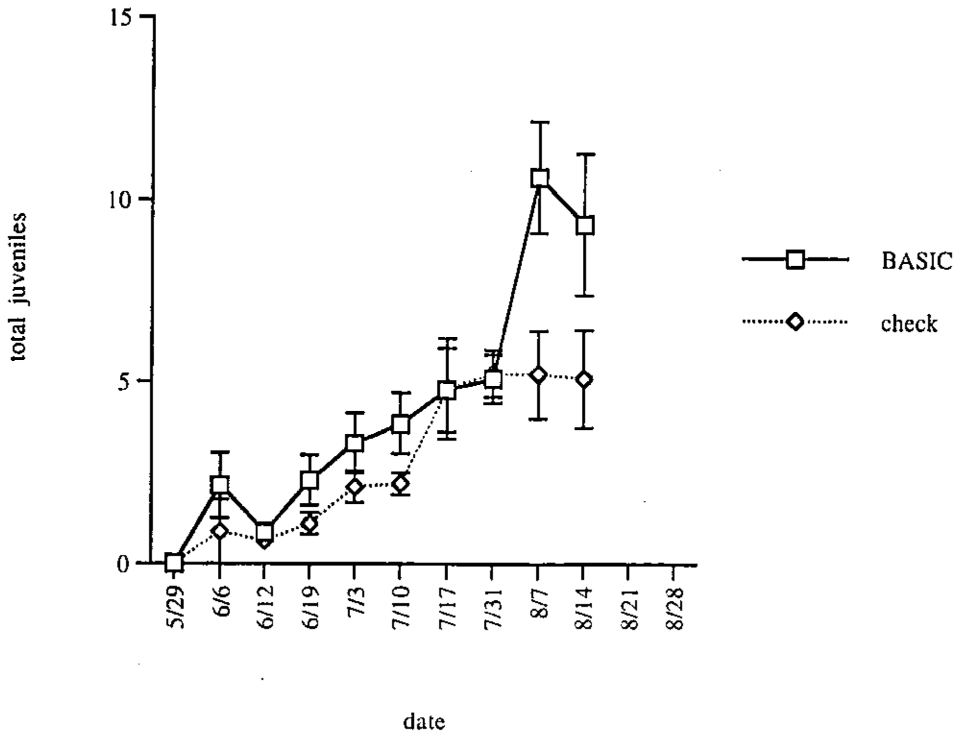

Figure 5a.
1997 BASIC leaf insects
percent mite

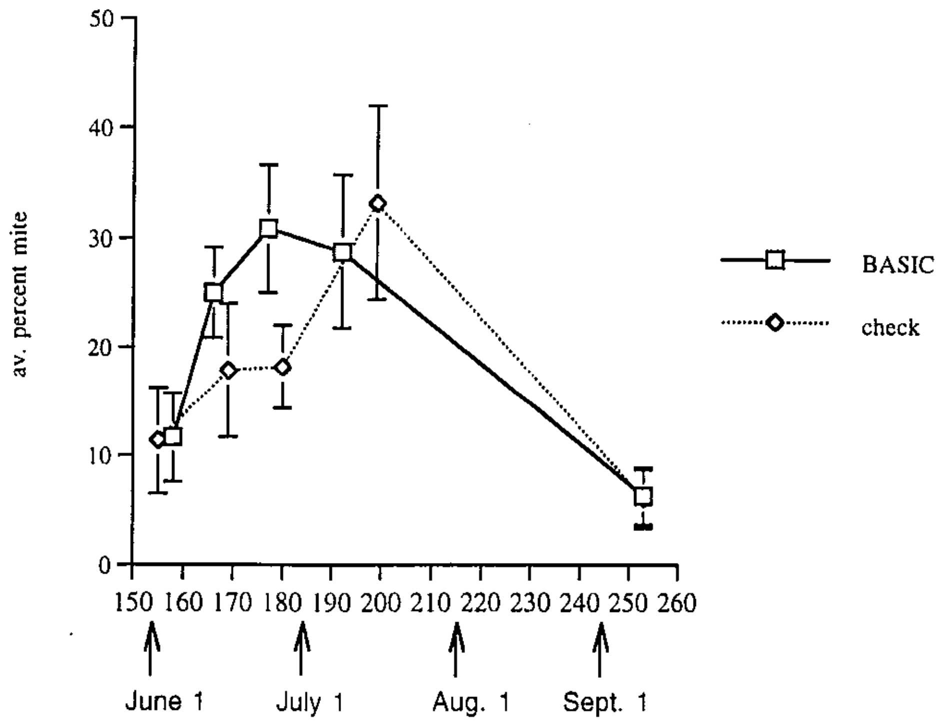

Figure 5b.
1997 BASIC Leaf Insects
mite rank

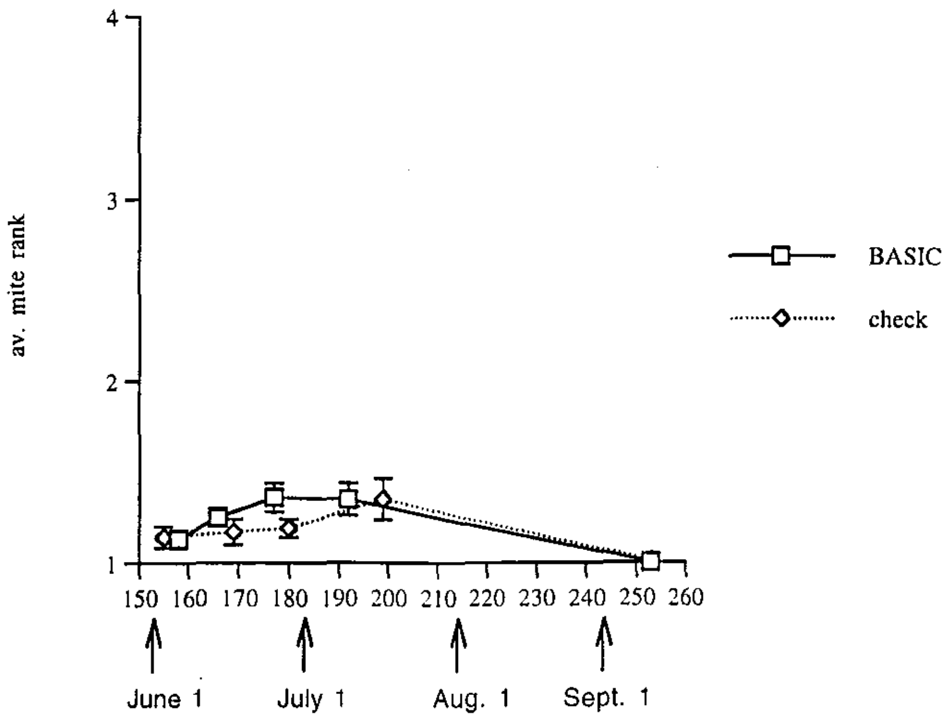

Figure 5c.
1997 BASIC leaf insects
thrips

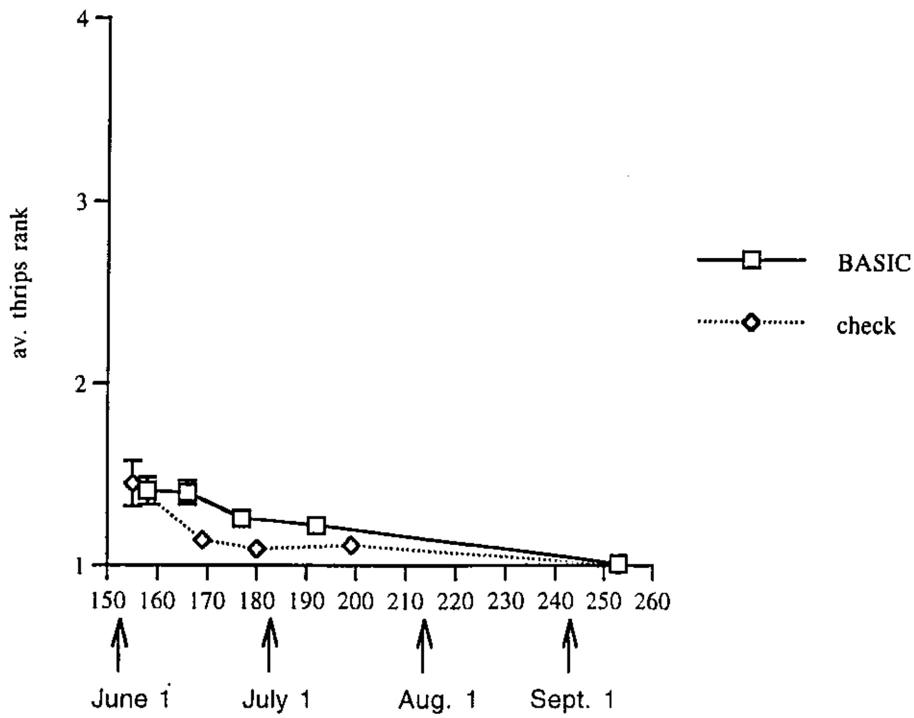

Figure 5d.
1997 BASIC leaf insects
aphids

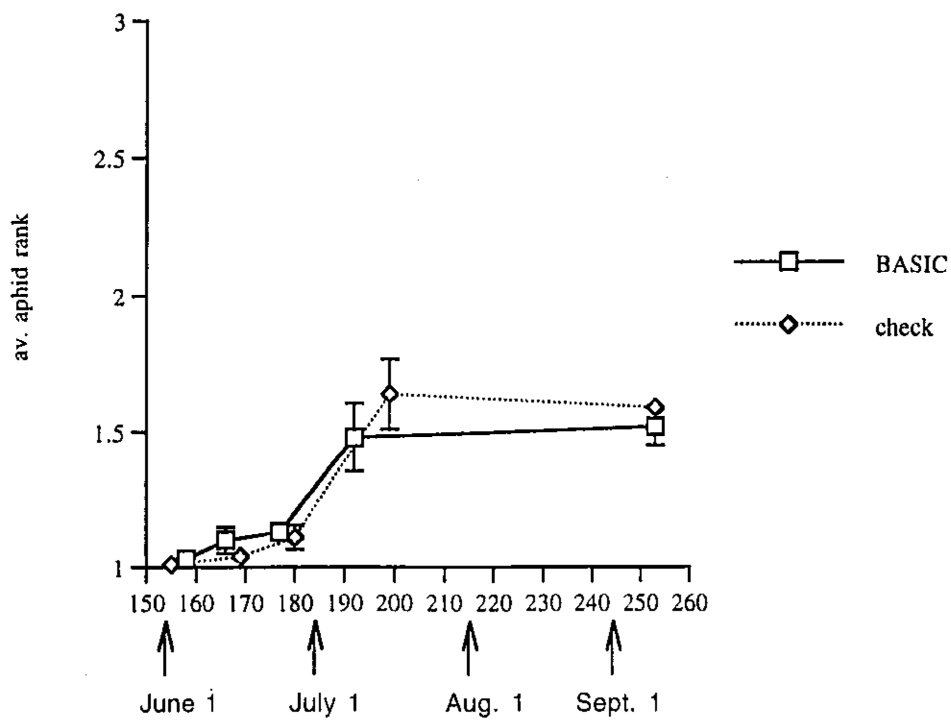

Figure 6a. 1997 BASIC
Effects of Flame Weeding on
Insect Populations -
Lygus

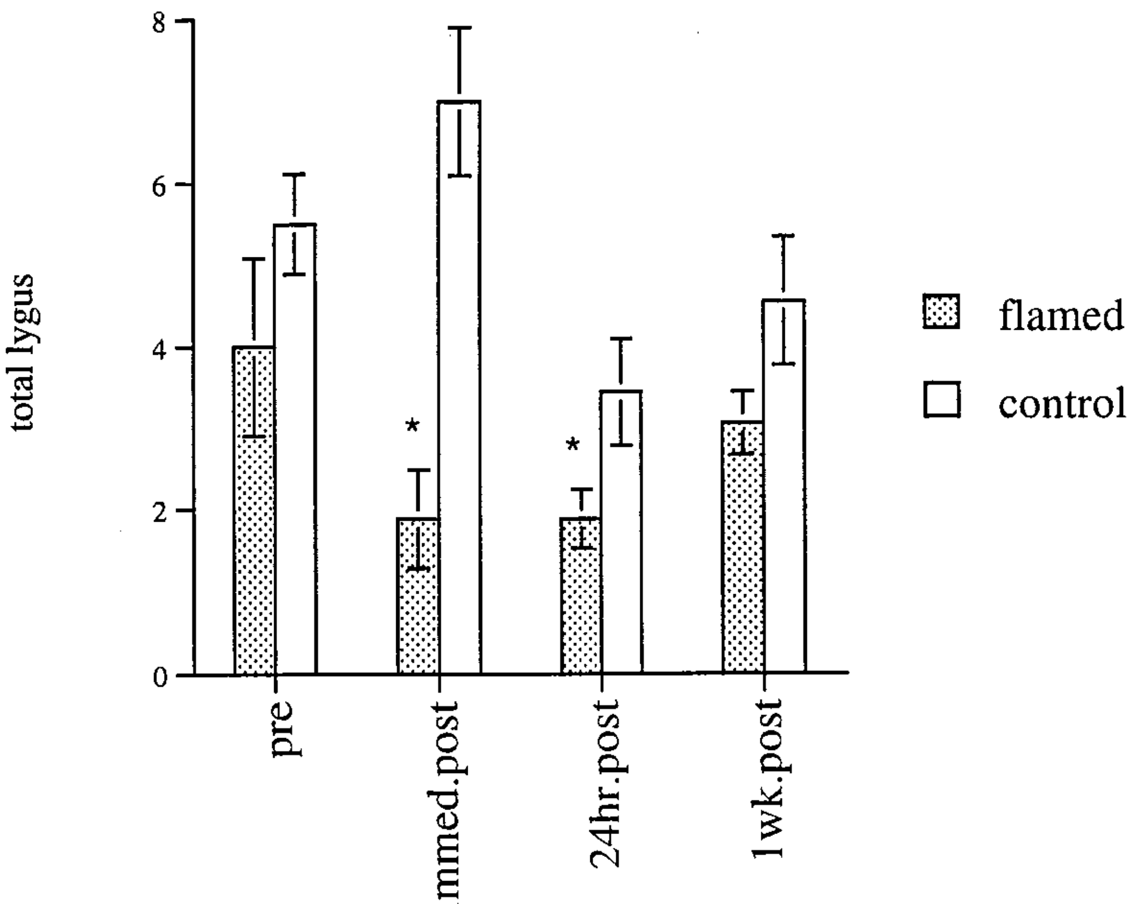

Figure 6b. 1997 BASIC
Effects of Flame Weeding on
Insect Populations -
Total Beneficial Insects

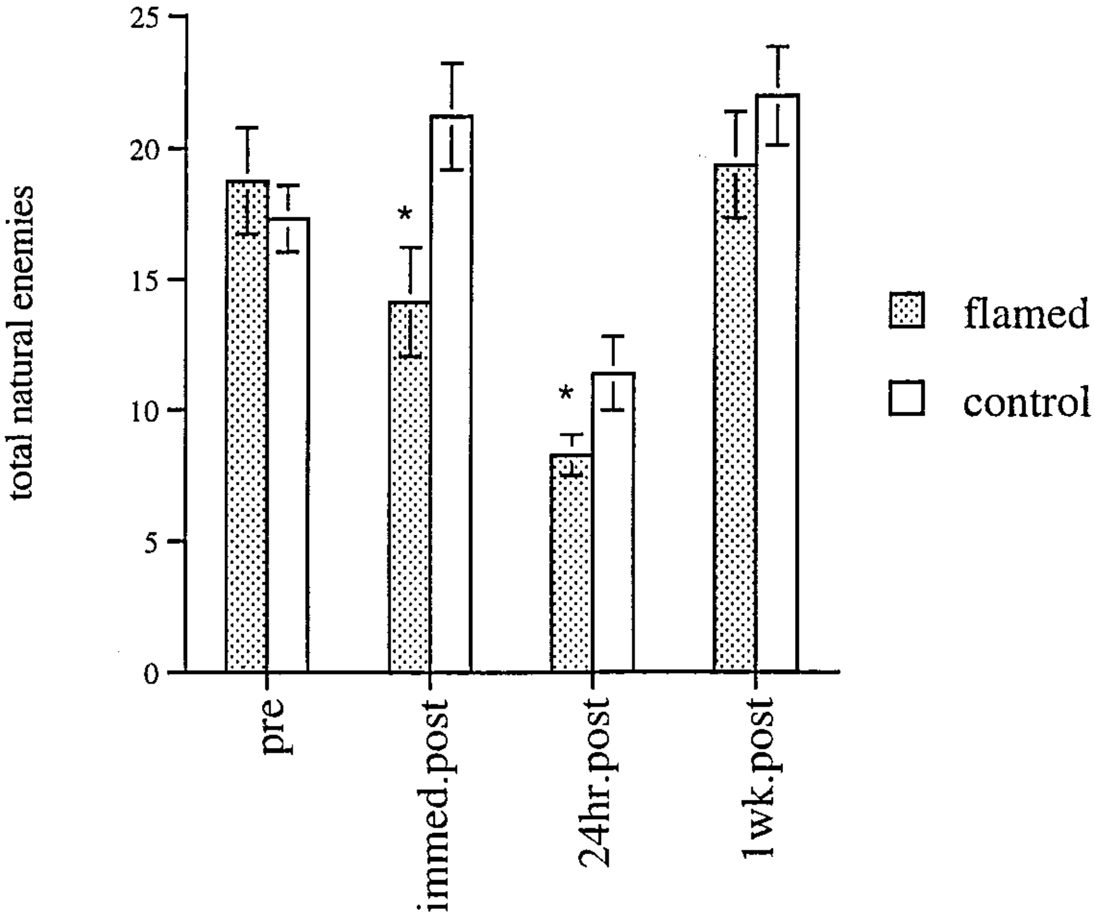

Figure 6c. 1997 BASIC
Effects of Flame Weeding on
Insect Populations -
Juvenile Beneficial Insects

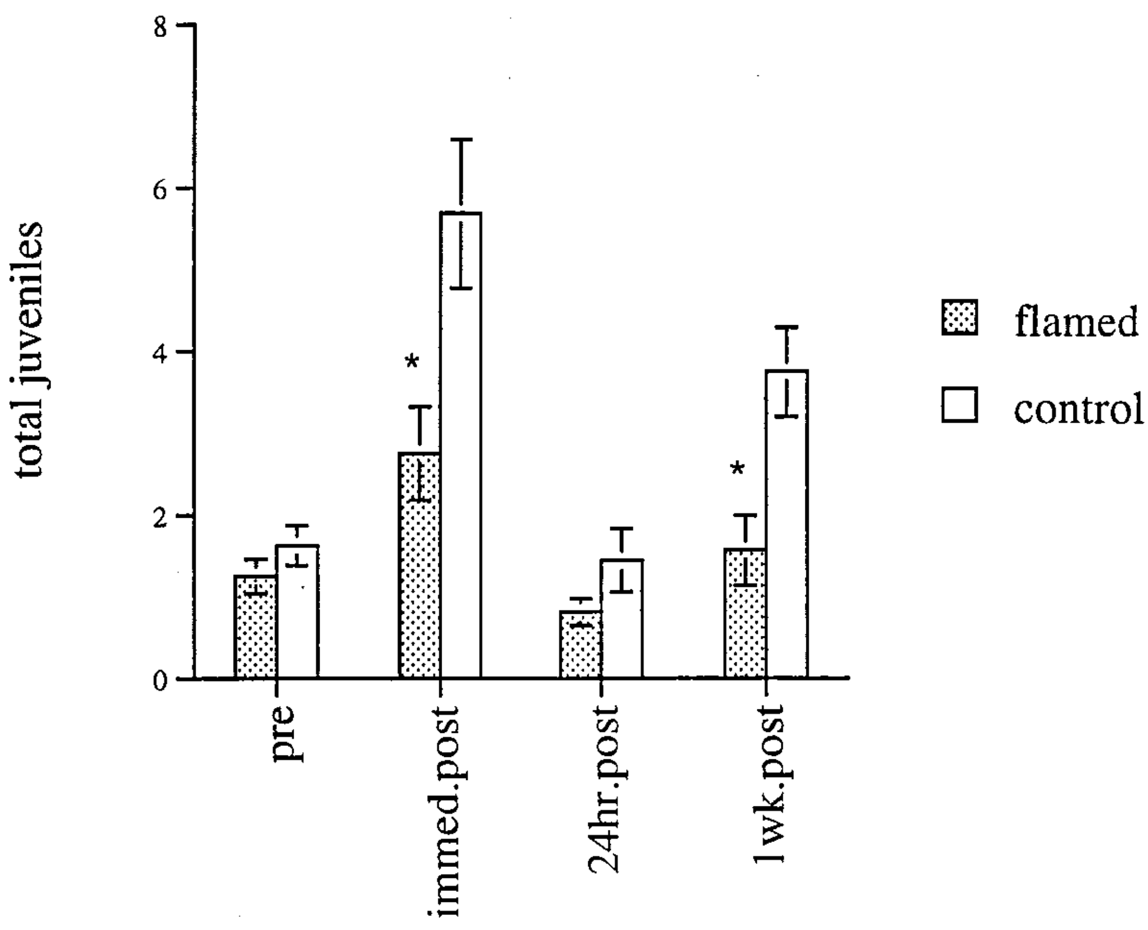

Figure 6d. 1997 BASIC
Effects of Flame Weeding on
Insect Populations -
Bigeyed bugs

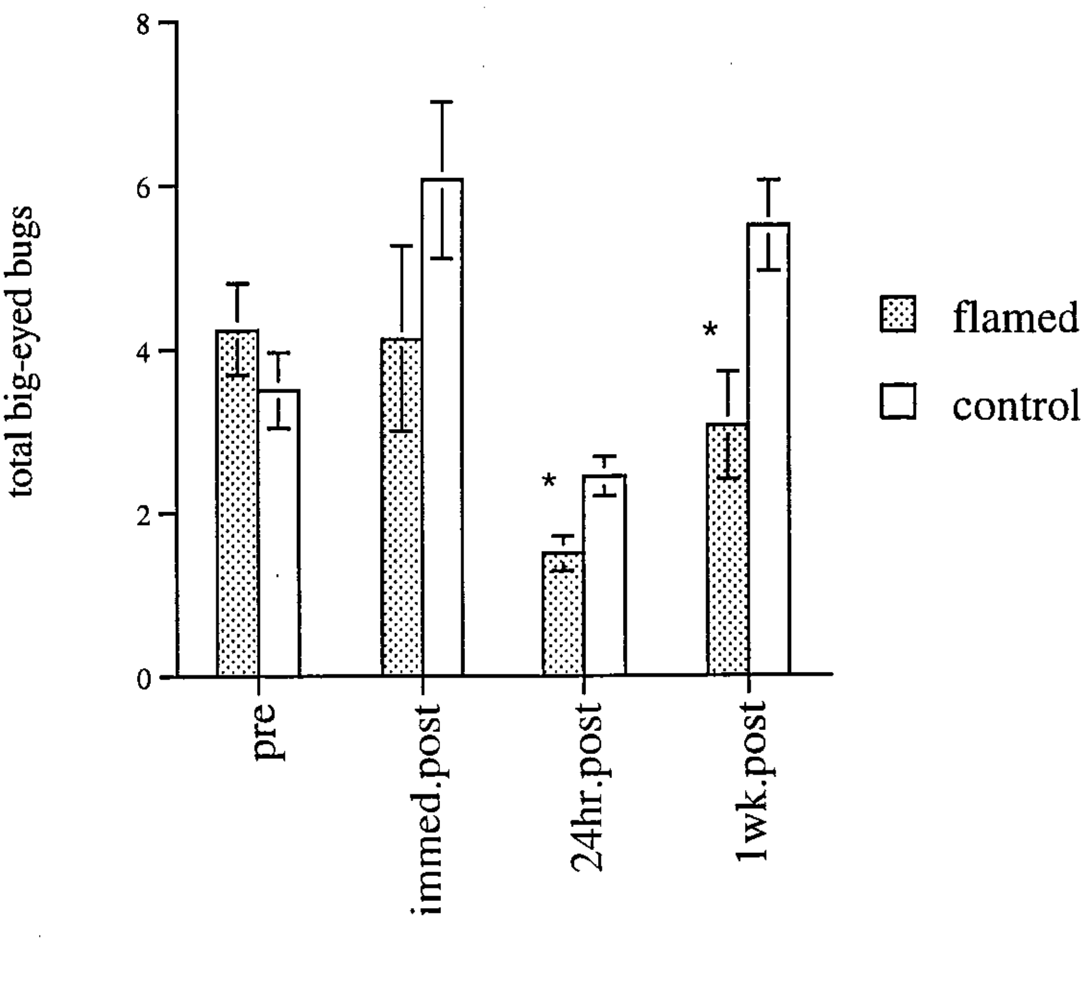

Figure 6e. 1997 BASIC
Effects of Flame Weeding on
Insect Populations -
Minute Pirate Bugs

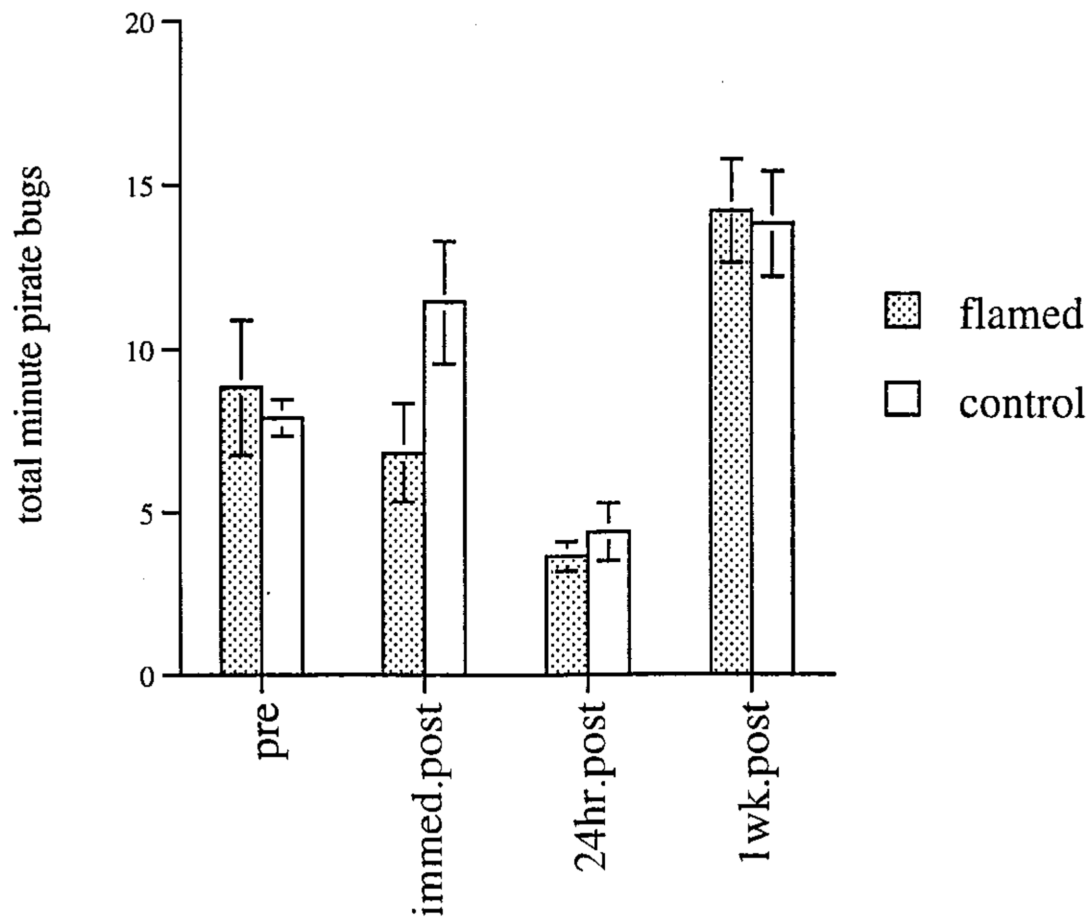

Figure 6f. 1997 BASIC
Effects of Flame Weeding on
Insect Populations -
Ladybird Beetles

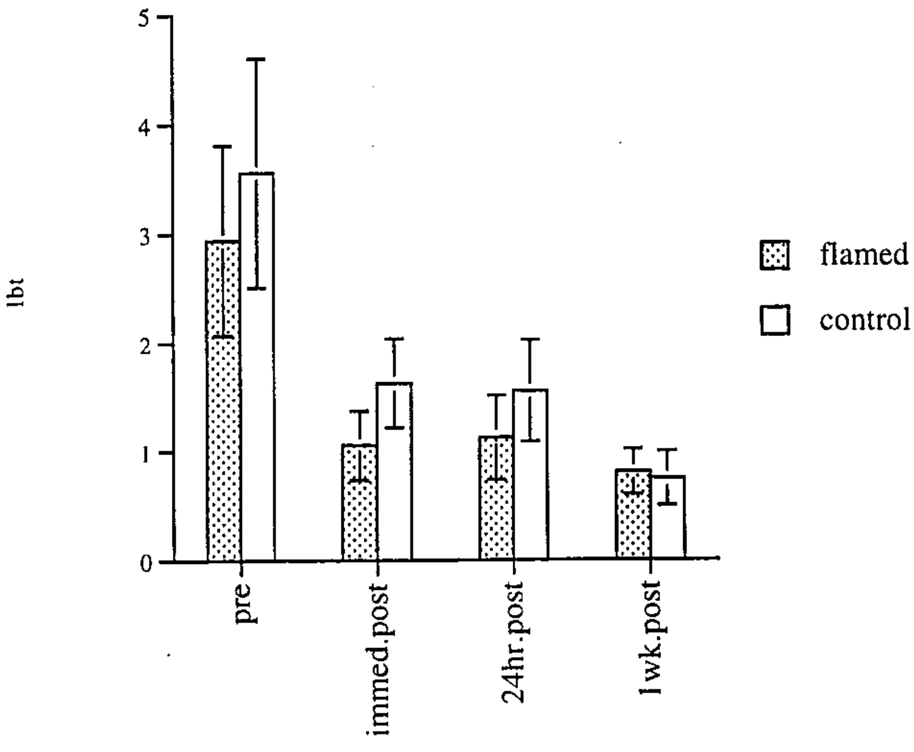

Table 1. 1996 CASFS BASIC Project
Average Per Acre Costs and Yields

		BASIC									
		LDO		All Organic		Non.-Organic		All BASIC		Conventional Checks	
		Average	S.E.	Average	S.E.	Average	S.E.	Average	S.E.	Average	S.E.
Cultural	Labor	106	2.0	104	2.2	105	8.0	104.4	3.3	110	4.4
	Field power	51	0.3	62	6.6	56	5.5	59.4	4.3	68	1.0
	Materials	146	7.3	154	7.2	241	38.3	192.4	22.0	300	29.0
	Custom/Rentals	228	43.4	290	45.0	121	22.4	214.6	41.1	158	29.9
	Total Cultural	530	37.9	609	52.4	523	56.0	570.8	39.4	637	54.6
Harvest	Labor	14	0.0	13	0.7	10	1.5	11.4	0.9	10	1.1
	Field power	47	0.0	43	2.7	31	6.3	37.3	3.6	30	4.4
	Materials	7	1.2	6	0.8	5	0.7	5.7	0.6	7	0.3
	*Custom/Rentals**	0	0.0	0	0.0	0	0.0	0.0	0.0	0	0.0
	Total Harvest	68	1.2	62	3.8	45	8.0	54.4	4.8	46	5.7
Interest		26	3.3	30	3.0	20	1.6	25.9	2.6	28	2.9
Assessments		11	2.0	10	1.1	10	1.3	10.3	0.8	13	0.6
Certification Fees		3	0.0	3	0.0	0	0.0	1.6	0.5	0	0.0
TOTAL COSTS/ACRE		638	38.0	714	51.1	599	53.7	663.1	41.0	724	57.0
YIELD (bales/acre)		2.12	0.39	2.04	0.22	1.98	0.25	2.0	0.2	2.49	0.16
TOTAL COST/BALE		324	65	367	44.3	313	48.1	343.1	32.3	291	9.6

* Ginning costs are paid by the gin, in return for the cottonseed from that cotton.